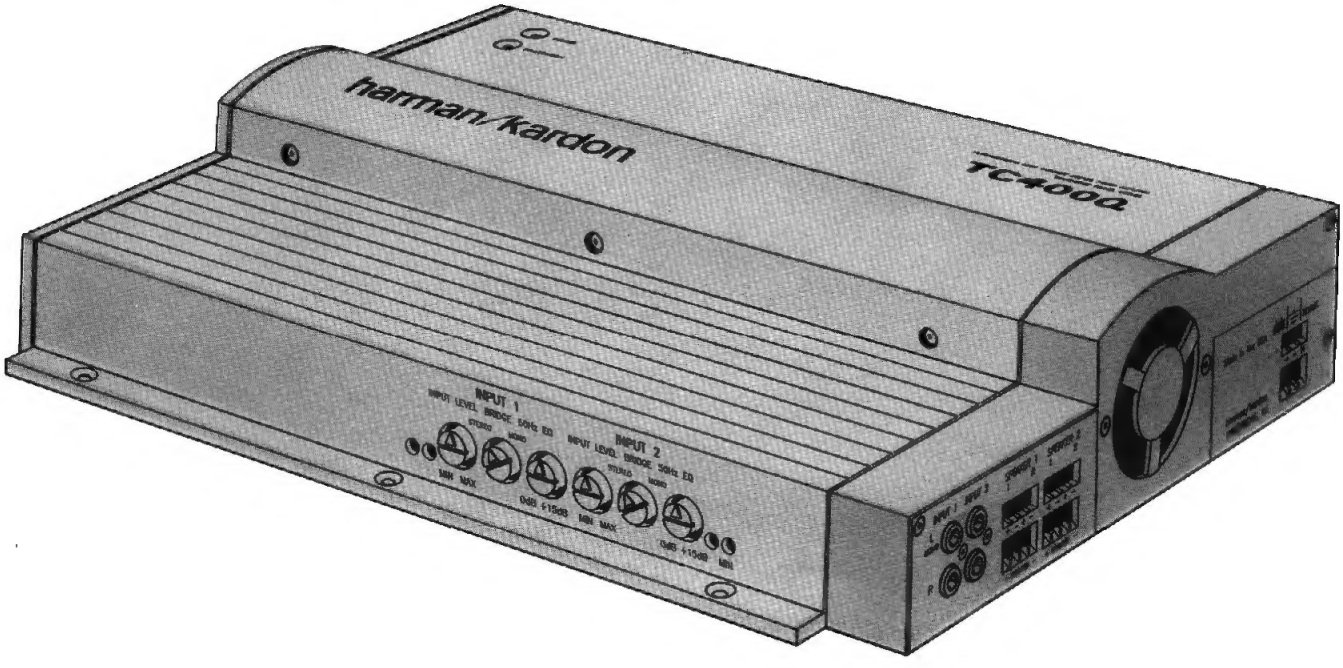
The Harman Kardon
TC400Q

Manual No. TC400Q-1

ULTRAWIDEBAND HIGH CURRENT TRANSVERSE TUNNEL COOLED STEREO POWER AMPLIFIER

Technical Manual



harman/kardon

8380 BALBOA BOULEVARD., NORTHRIDGE CA 91325
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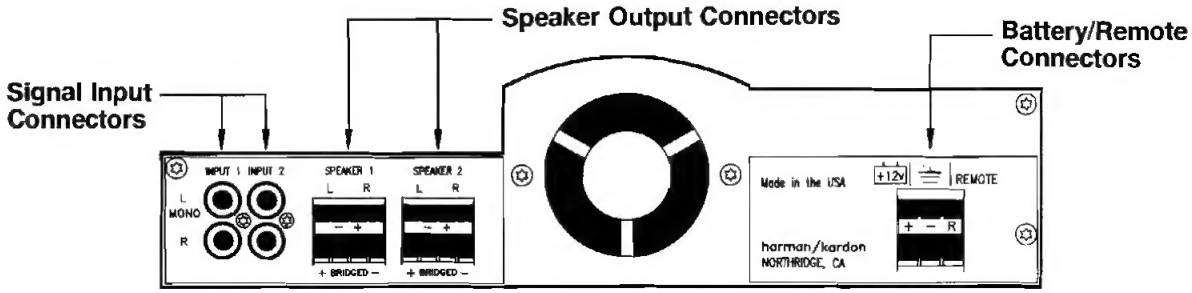
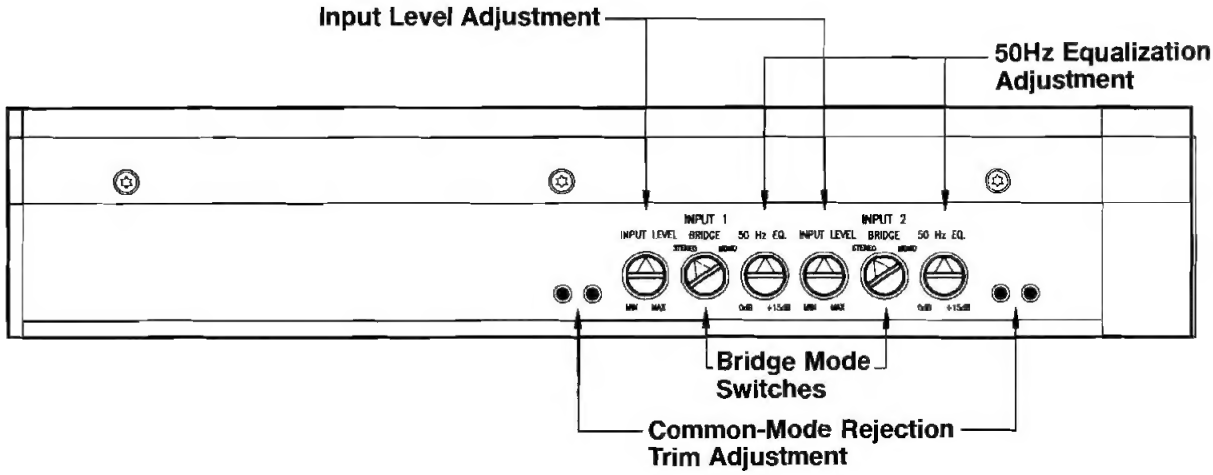
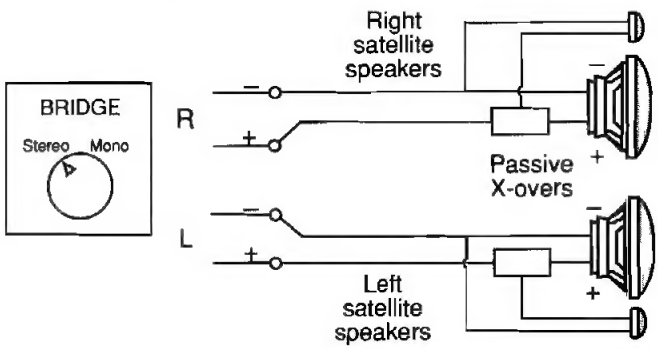
COMPONENTS AND THEIR FUNCTION

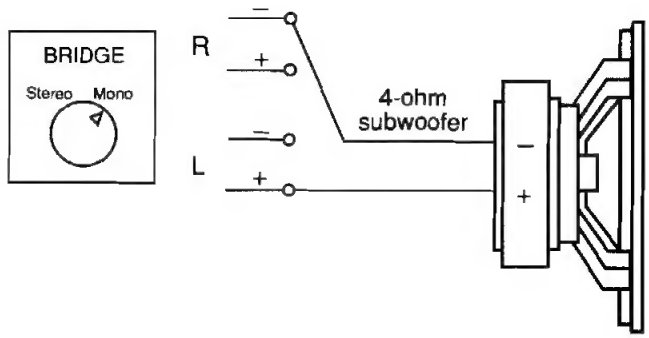




SPEAKER CONNECTION FOR STEREO OPERATION



SPEAKER CONNECTION FOR BRIDGED/MONO OPERATION



SPECIFICATIONS

Power Output, RMS	400Watts continuous power 70Wx4 channels @ 4 ohms 100Wx4 channels @ 2 ohms 70Wx2 channels @ 4 ohms +200Wx1 channel @ 4 ohms 100Wx2 channels @ 2 ohms +200Wx1 channel @ 4 ohms 200Wx 2 channels @ 4 ohms
HCC (High Instantaneous Current Capability):	±50A
THD (4 ohms/2 ohms):	No more than 0.1%/0.2%
Negative Feedback	25dB
Frequency Response:	10Hz to 100 kHz, +0, -3dB
Signal-To-Noise Ratio: (referred to rated power)	100dB
Input Sensitivity: (Continuously Variable Line Level to High-Level)	0.25V to 2.5V
Input Impedance	
Center pin connector (+)	22kohms
Outside shield (-)	22kohms
Power supply:	DC +14.4V (9V - 16V usable), negative ground
Typical Current Requirements:	
At Idle	6.0A
Full powerr music signal	13.3A (4 ohms/channel)
Full power music signal	20A (2 ohms/channel)
Full pwer sine wave	40A (4 ohms/channel)
Full power sine wave	60A (2 ohms/channel)
Dimensions (LxWxH)	16-5/8" x 12-7/8" x 3-1/4" 422 x 327 x 83 (mm)
Weight	14lbs. 12oz. (6.7 kg)

DISASSEMBLY PROCEDURES

NOTE: Before trying to disassemble the TC400Q, disconnect all wiring.

STEP 1

Remove right and left hand End Panels by unscrewing five 6-32x1 3/4" (Ref. No. 085) on the right hand End Panel and two 4-40x9/16" (Ref. No. 080) on the right hand End Panel and five 6-32x1/2" (Ref. No. 070) on the left hand End Panel.

STEP 2

Remove three screws 6-32x5/16" (Ref. No. 075) from the side of the Center Cover (Ref. No. 025).

STEP 3

Remove six screws 6-32x1/4" (Ref. No. 090) from the underside of the Bottom Cover and carefully lift the top cover assembly off. Carefully remove the Fan Assembly plug (Ref. No. J1) and LED Assembly plug (Ref. No. J2) from the Printed Circuit Board Assembly.

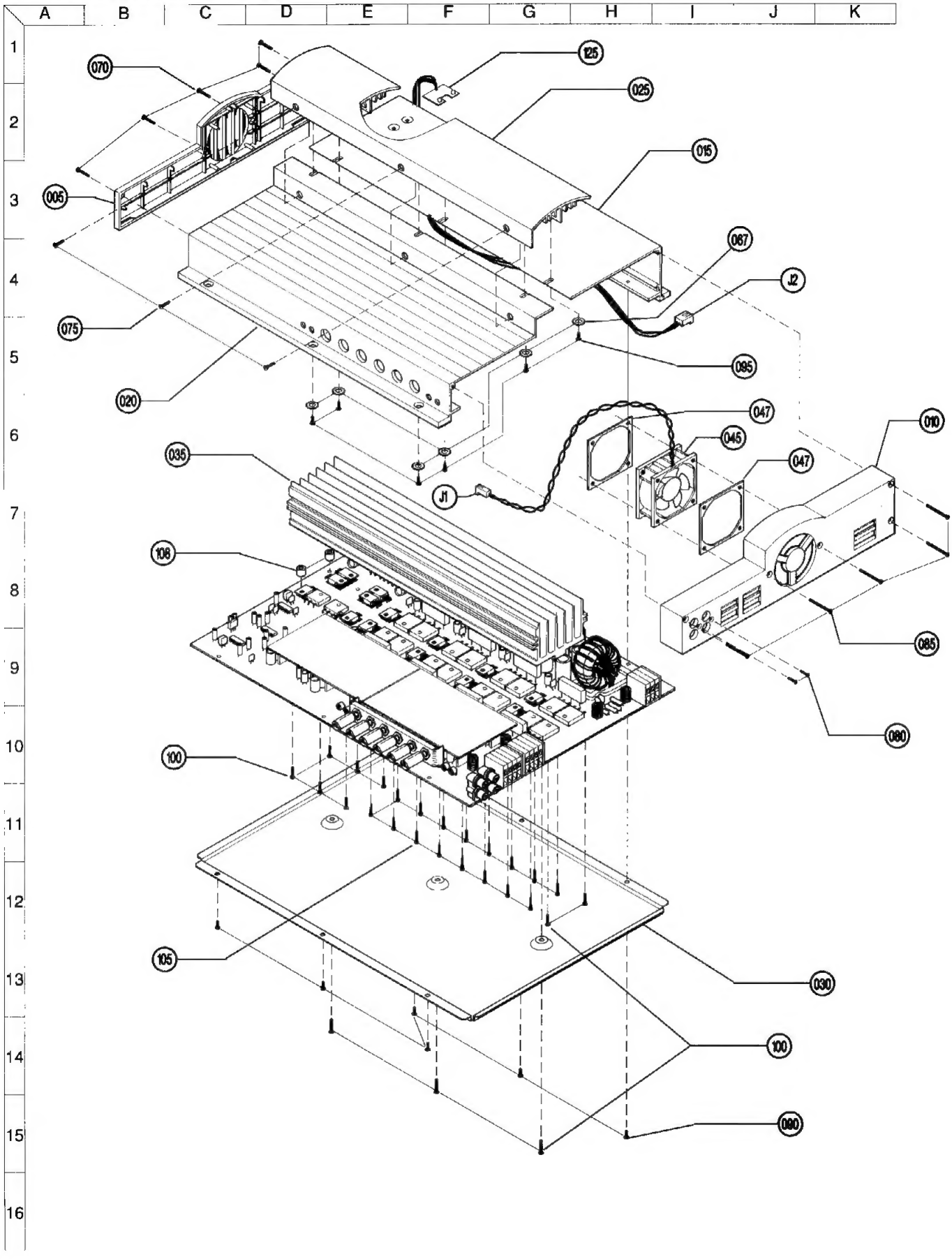
STEP 4

To remove the Bottom Cover from the Printed Circuit Board Assembly unscrew three screws 6-32x1/2" (Ref. No. 100). To remove the Heatsink unscrew the remaining eight screws 6-32x1/2" and sixteen screws 4-40x1/2" (Ref. No. 105). Carefully lift the circuit board off of the heatsink.

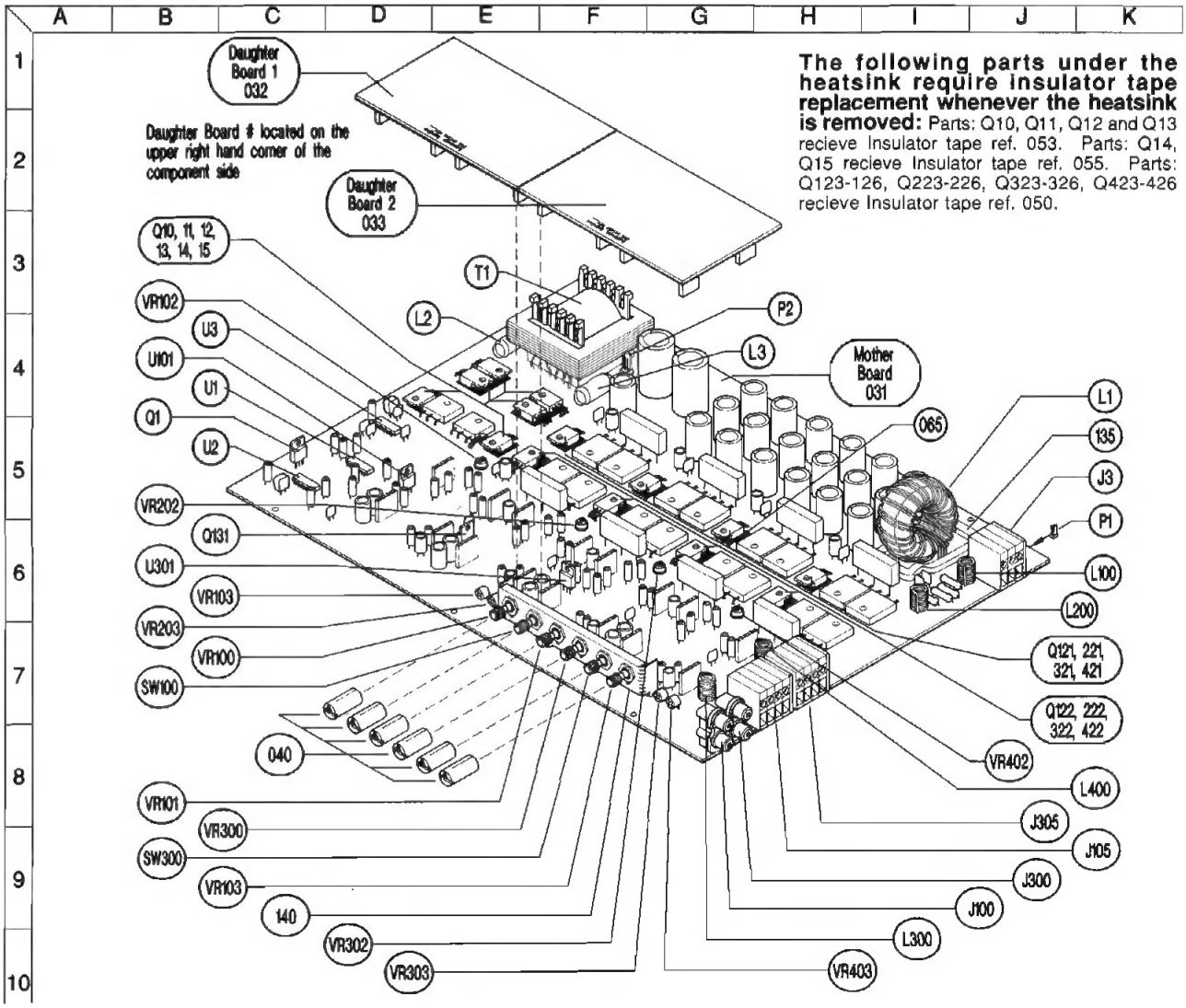
REPLACEMENT OF PARTS

If it is determined that a part under the heatsink requires replacement, carefully desolder the part's leads using solder wicking braid and a soldering iron; it may be necessary to wick away solder on both sides of the board. Remove and verify the part's failure. Replace the part with a known good part making sure to form a part's leads to match those of the removed part. Make sure that any shimming or other supporting materials remains attached to the circuit board. In particular, if replacement of Q120 and/or Q220 and/or Q320 and/or Q420 is necessary, make sure that the flat surfaces of these parts are parallel to the circuit board. If necessary clean and reapply thermal compound to the heatsink mounting surface. **NOTE: It is important to replace Insulator tape ref. 050, 053 and 055 each time the Heatsink is reattached to the Mother Board.** With the mounting surface of the heatsink facing upward, turn the board upside down and carefully position over the heatsink, visually aligning the mounting holes of sink and board. Reinstall the fourteen screws using a torque wrench set to 8 inch-pounds. The remainder of assembly is the reverse of disassembly.

GENERAL ASSEMBLY EXPLODED VIEW



PCBA EXPLODED VIEW



The following parts under the heatsink require insulator tape replacement whenever the heatsink is removed: Parts: Q10, Q11, Q12 and Q13 recieve Insulator tape ref. 053. Parts: Q14, Q15 recieve Insulator tape ref. 055. Parts: Q123-126, Q223-226, Q323-326, Q423-426 recieve Insulator tape ref. 050.

PARTS LIST FOR THE BLACK AND SILVER UNIT

Ref. No.	Part No.	Description
005	50481-002	End Panel , Left Hand, Black
	50481-001	End Panel , Left Hand, Silver
010	51202-002	End Panel , Right Hand, Black
	51202-001	End Panel , Right Hand, Silver
015	50581-002	Cover, Upper, Black
	50581-001	Cover, Upper, Silver
020	50582-002	Cover, Lower, Black
	50582-001	Cover, Lower, Silver
025	50583-002	Cover, Center, Black
	50583-001	Cover, Center, Silver
030	52210-001	Cover, Bottom
031	52817-001	Mother Board
032	52819-001	Daughter Board 1 (specify part# and
033	52819-001	Daughter Board 2 board# when ordering)
035	50580	Heatsink
040	50896-001	Knob
045	265018	Fan Assembly
047	50619	Fan Gasket
050	264894-001	Insulator, 1.75x1.12
053	264883-001	Insulator, .5x1
055	264883-002	Insulator, .5x.5

Ref. No.	Part No.	Description
065	264971	Shim, .030Thick
067	59101-001	Washer #6, external tooth
070	51926-001	Screw, 6-32 x 3/4
075	51221	Screw, 6-32 x 1/4
080	51222	Screw, 4-40 x 9/16
085	51924-001	Screw, 6-32 x 1 3/4
090	51189	Screw, 6-32 x 1/4
095	51319	Screw, 6-20 x 3/8
100	263789	Screw, 6-32 x 1/2
105	263734	Screw, 4-40 x 1/2
108	51886-001	Spacer, Nylon, .147ID, .250OD
125	51889-001	LED Assembly
135	51859-001	frame, coil, potting
140	51199	Support Bracket for Controls
J1	-----	part of Ref. No. 045
J2	-----	part of Ref. No. 125
J3	50397	Terminal, Block, 3Pole
J100, 200, 300, 400	50660	Jack, 4Pin, RCA
J101, 102, 103, 104, 201, 202 203, 204, 301, 302, 303 304, 401, 402, 403, 404	265557	CONN, SKT, STR, 6P, .335"H
J105, 305	50398	Terminal, Block, 4Pole
P1	50892	Connector, 2Pin
P2	50999	Connector, 3Pin
P101, 102, 103, 104 201, 202, 203, 204 301, 302, 303, 304 401, 402, 403, 404	265568	Header, strip, 6Pin, 0.1"spacing, shrouded
SW100, 300	50709	Switch, Rotary
	INDUCTORS	
L1	50641	560µH, Inductor, Input
L2,3	50635	5µH, Inductor, Smoothing
L100, 200, 300, 400	50638	1µH, Inductor, Output
T1	262083	Transformer, High Frequency Power
	INTEGRATED CIRCUITS	
U1	52211-001	IC, LM324N, MOTOROLA
U2	262061	IC, LM74C14N, HEX, INV
U3	50621	IC, SG3525A
TS1	51012	IC, LM35D
U101, 301	HM13-040	MC7915CT
	RESISTORS	
ER100, 101,200, 201,300 301, 400, 401	50578-001	0.22Ω, 3W
R1	182-02000-00	200Ω, ±5%, 1/2W
R2, 29, 48	50392-015	20K, ±5%, 1/8W
R3	26212	22Ω, ±5%, 1/8W
R4, 12, 13, 22, 25, 30,32 47. 54	HM185-01003-00	100K, ±5%, 1/8W
R5	HM184-02321-00	2.32K, ±5%, 1/8W
R6, 45, 51	186-02742-00	27.4K, ±1%, 1/8W
R7, 36, 38, 169, 170, 269 270, 369, 370, 469, 470	HM185-01001-00	1K, 5%, ±1/8W
R8, 50	HM185-04701-00	4.7K, 5%, ±1/8W
R9	50180-17	2.15K, ±1%, 1/8W
R10, 14, 21, 52, 56, 72 74, 76, 78	HM185-01002-00	10K, ±5%, 1/8W
R11181-06200-00	620Ω, 5%, 1/4W	
R15	50900-002	82Ω, ±5%, 1/2W
R16	50180	6.65K, ±1%, 1/8W
R17	HM186-01002-00	10K, ±1%, 1/8W
R18	186-01582-00	15.8K, ±1%, 1/8W

Ref. No.	Part No.	Description
R19	50392-033	510K, ±5%, 1/8W
R20	HM185-04703-00	470K, ±5%, 1/8W
R23, 42	50392-024	5.1K, ±5%, 1/8W
R24	C185-01802-00	18K, ±5%, 1/8W
R26, 40	C185-03902-0	39K, ±5%, 1/8W
R27	C185-02001-00	2K, ±5%, 1/8W
R28	C185-01501-00	1.5K, ±5%, 1/8W
R31	HM185-03900-00	390Ω, ±5%, 1/8W
R33	50180-131	249Ω, ±1%, 1/8W
R34	50180-178	1.78K, ±1%, 1/8W
R35, 167, 267, 367, 467	C185-02401-00	2.4k, ±5%, 1/8W
R37, 161, 261, 361, 461	C185-01000-00	100Ω, ±5%, 1/8W
R39	262136	4.3MEG, ±5%, 1/8W
R41	262147	5.1MEG, ±5%, 1/8W
R44	50392-002	24K, ±5%, 1/8W
R46	5232-335J16	3.3MEG, ±5%, 1/8W
R49	HM185-01004-00	1MEG, ±5%, 1/8W
R55	HM181-09100-00	910Ω, ±5%, 1/4W
R57, 58, 59, 60, 61, 62 109, 136, 209, 236, 309 336, 409, 436	50392-017	33Ω, ±5%, 1/8W
R63	C185-03302-00	33K, ±5%, 1/8W
R64	HM185-01502-00	15K, ±5%, 1/8W
R65, 66	50392-018	200Ω, ±5%, 1/8W
R70	R025-1552	22Ω, ±5%, 1/4W
R71, 73, 75, 77	HM185-03002-00	30K, ±5%, 1/8W
R80, 81, 82, 83	50392-004	10Ω, ±5%, 1/8W
R85, 271, 274, 371, 471, 472	HM185-10000-00	0Ω (jumper resistor), ±5 %, 1/8W
R100, 201, 300, 401	50180-107	3.65K, ±1%, 1/8W
R101, 200, 301, 400	50180-106	4.53K, ±1%, 1/8W
R102, 103, 202, 203, 302 303, 402, 403	50180-04	4.99K, ±1%, 1/8W
R104, 204, 304, 404	50180-004	8.25K, ±1%, 1/8W
R105, 205, 305, 405	186-09090-00	909Ω, ±1%, 1/8W
R106, 113, 206, 213, 306 313, 406, 413	C185-03301-00	3.3K, ±5%, 1/8W
R107, 207, 307, 407	C185-03902-00	39K, ±5% , 1/8W
R108, 208, 308, 408	50180-077	11K, ±1%, 1/8W
R110, 210, 310, 410	C185-01000-00	100Ω, ±5%, 1/8W
R111, 118, 211, 218, 311 318, 411, 418	HM185-01800-00	180Ω, ±5%, 1/8W
R112, 212, 312, 412	50180-033	2K, ±1%, 1/8W
R114, 214, 314, 414	HM186-03321-00	3.32K, ±1%, 1/8W
R115, 215, 315, 415	HM186-03922-00	39.2K, ±1%, 1/8W
R116, 216, 316, 416	50180-078	8.87K, ±1%, 1/8W
R117, 217, 317, 417	186-01000-00	100Ω, ±1%, 1/8W
R119, 219, 319, 419	261944	2.67K, ±1%, 1/8W
R121, 137, 141, 221, 237 241, 321, 337, 341 421, 437, 441	50180-172	2.21K, ±1%, 1/8W
R122, 222, 322, 422	258932	1.40K, ±1%, 1/8W
R123, 124, 223, 224, 323 324, 423, 424	186-01582-00	15.8K, ±1%, 1/8W
R125, 225, 325, 425	258921	46.4Ω, ±1%, 1/8W
P126, 226, 326, 426	50180-065	2.37K, ±1%, 1/8W
R127, 227, 327, 427	50180-198	698Ω, ±1%, 1/8W
R128, 228, 328, 428	50180-019	150K, ±1%, 1/8W
R129, 229, 329, 429	186-06190-00	619Ω, ±1%, 1/8W
R130, 230, 330, 430	C185-02702-00	27K, ±5%, 1/8W
R131, 231, 331, 431	HM186-01302-00	13K, ±1%, 1/8W
R133, 233, 333, 433	C185-06800-00	680Ω, ±5%, 1/8W
R135, 146, 235, 246, 335 346, 435, 446	50180-118	10.5K, ±1%, 1/8W
R138, 140, 238, 240, 338 340, 438, 430	50180-182	549Ω, ±1%, 1/8W
R139, 239, 339, 439	HM185-08201-00	8.2K, ±5%, 1/8W

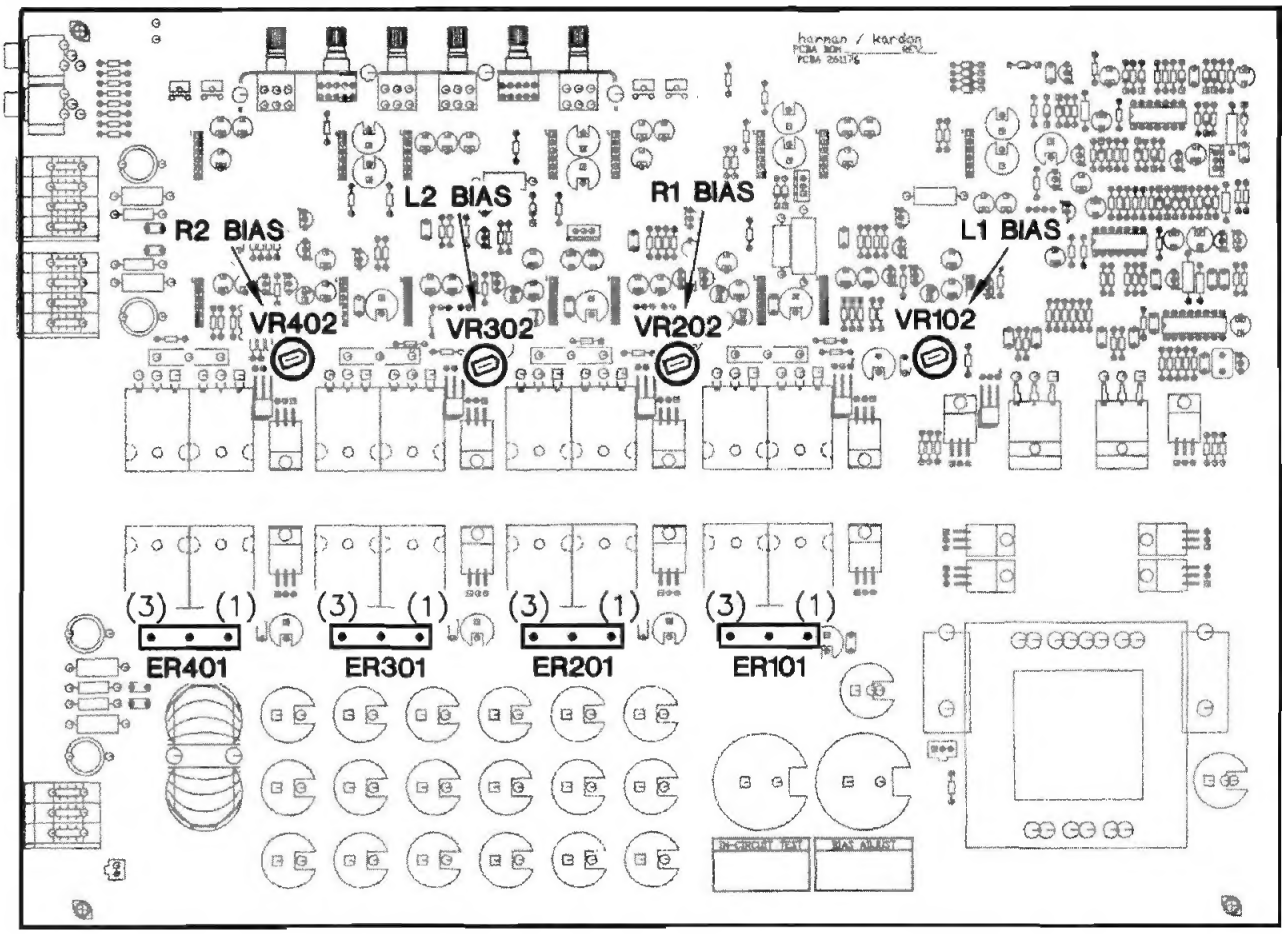
Ref. No.	Part No.	Description
R142, 242, 342, 442	50180-183	147Ω, ±1%, 1/8W
R143, 243, 343, 443	HM185-04700-00	470Ω, ±5%, 1/8W
R144, 244, 344, 444	HM181-03301-00	3.3K, ±5%, 1/4W
R145, 245, 345, 445	50180-00	1K, ±1%, 1/8W
R147, 247, 347, 447	50392-004	10Ω, ±5%, 1/8W
R148, 151, 248, 251, 348 351, 448, 451	186-30100-00	30.1Ω, ±1%, 1/8W
R149, 249, 349, 449	186-01210-00	121Ω, ±1%, 1/8W
R150, 250, 350, 450	258919	56.2Ω, ±1%, 1/8W
R152, 153, 252, 253, 352 353, 452, 453	50199-021	20K, ±1%, 1/4W
R154, 254, 354, 454	186-01180-00	118Ω, ±1%, 1/8W
R155, 255, 355, 455	C185-24700-00	4.7Ω, ±5%, 1/8W
R156, 157, 256, 257, 356 357, 456, 457	50180-109	475Ω, ±1%, 1/8W
R159, 259, 359, 459	255051	332Ω, ±1%, 1/8W
R160, 260, 360, 460	262158	274Ω, ±1%, 1/8W
R162, 168, 262, 268, 362 368, 462, 468	HM185-02201-00	2.2K, ±5%, 1/8W
R163, 263, 363, 463	C185-06800-00	680Ω, ±5%, 1/8W
R164, 264, 364, 464	HM185-07500-00	750Ω, ±5%, 1/8W
R165, 265, 365, 465	50392-036	510Ω, ±5%, 1/8W
R166, 266, 366, 466	C185-03301-00	3.3K, ±5%, 1/8W
R173, 273, 373, 473	256999	0.56Ω, ±5%, 1W
R176, 276, 376, 476	R125-1524	10Ω, ±5%, 1W
R177	262994	91Ω, ±5%, 2W
R178	262103	750Ω, ±5%, 1W
R179, 180	50728-004	150Ω, ±5%, 1W
VR100, 101, 200, 201, 300 301, 400, 401	51122	Potentiometer, 100K, Reverse, LOG
VR102, 202, 302, 402	52266-001	Potentiometer 200Ω, Trim
VR103,203,303,403	51993-001	Potentiometer 2K, Trim, Right, Angle

CAPACITORS

C1, 2, 8, 10, 112, 212, 312, 412	HM14-0582	CAP-SF, 0.1μF, ±5%, 50V
C3	HM14-0752	0.47μF, ±5%, 50V
C4, 106, 206, 306, 406	256746	1μF, ±5%, 50V
C5	HM14-0594	0.0033μF, ±5%, 50V
C6	52197-001	4.7μF, ±20%, 50V
C7	HM14-0581	0.047μF, ±5%, 50V
C11, 12, 13, 14	14-0291	0.001μF, ±10%, 1KV
C100, 200, 300, 400	50436-001	150pF, ±5%, 50V, NPO
C101, 201, 301, 401	C050-1628	180pF, ±5%, 63V, COG
C103, 203, 303, 403	51711-002	22pF, ±5%, 500V, NPO
C107, 207, 307, 407	HM14-0582	0.1μF, ±5%, 50V
C108, 208, 308, 408	HM14-0595	0.001μF, ±5%, 50V
C109, 209, 309, 409	C050-0033	33pF, 100V, COG
C110, 210, 310, 410	HM14-0582	CAP-SF, 0.1μF, ±5%, 50V (on mother board)
C110, 210, 310, 410	51711-002	22pF, ±5%, 500V, NPO (on daughter board)
C111, 211, 311, 411	HM14-0582	CAP-SF, 0.1μF, ±5%, 50V (on mother board)
C111, 211, 311, 411	51920-001	680pF, ±5%, 50V (on daughter board)
C114, 214, 314, 414	HM14-0681	0.039μF, ±5%, 50V (on mother board)
C114, 214, 314, 414	258943	82pF, ±5%, NPO (on daughter board)
CP1	HM14-0576	22μF, ±20%, 25V
CP2, 101, 104, 201, 204, 301 304, 401, 404	50681-001	4.7μF, ±20%, 50V
CP3, 7, 110, 111, 115, 116, 122, 123, 211, 215, 216, 311, 315, 316, 322, 323, 411, 415, 416	C035-1528	10μF, ±20%, 35V
CP4, 5	HM14-0577	1μF, 50V
CP6	263833	47μF, ±20%, 16V, Lo-Profile
CP9	HM14-0567	22μF, 25V, 85C
CP10	255828	10μF, 25V, R, TR
CP11	50911-003	3.3μF, 50V, 10
CP12	C015-0100	100μF, 25V

Ref. No.	Part No.	Description
CP13-32	HM14-0574	470µF, 35V, 105C
CP33, 34	50362-003	10,000µF, ±20%, 35V
CP105, 106, 205, 206 305, 306, 405, 406	263745	1000µF, ±20%, 16V, Lo-Profile
CP107, 118, 119, 207, 218, 219, 307, 318 319, 407, 418, 419	C14-0646	100µF, 10V, RAD
CP108, 208, 308, 408	263833	47µF, ±20%, 16V, Lo-Profile
CP109, 209, 309, 409	C14-0646	100µF, 10V, RAD (on mother board)
CP109, 110, 209, 210, 309 310, 409, 410	50681-001	4.7µF, ±20%, 50V (on daughter board)
CP110, 111, 210, 310, 410	C035-1528	10µF, ±20%, 35V (on mother board)
CP112, 212, 312, 412	51077-001	220µF, ±20%, 16V
CP117, 217, 317, 417	51077-001	220µF, ±20%, 16V
CP120, 121, 220, 320 420, 221, 321, 421	C050-1607	100µF, ±20%, 50V
	TRANSISTORS	
Q1, 131	HM13-0418	TIP31C
Q2, 9, 18, 119, 129, 130 219, 229, 230, 319, 329 330, 419, 429, 430	HM13-0414	2N3906
Q3, 16	HM13-0416	2N4403
Q5, 6, 7, 17	HM13-0413	2N3904
Q10, 11, 12, 13, 14, 15	50157	MTP50NO5E
Q100, 108, 200, 208, 300 308, 400, 408	S100-152	2N5210
Q101, 104, 109, 116, 201 204, 209, 216, 301, 304 309, 316, 401, 404, 409, 416	HM13-0414	2N3906
Q102, 103, 105, 106, 112 202, 203, 205, 206, 212 302, 303, 305, 306, 312 402, 403, 405, 406, 412	HM13-0413	2N3904
Q107, 207, 307, 407	HM13-0416	2N4403
Q110, 111, 115, 118 210, 211, 215, 218 310, 311, 315, 318 410, 411, 415, 418	HM13-0415	MPS8099
Q113, 114, 117, 213, 214 217, 313, 314, 317, 413 414, 417	HM13-0417	MPS8599
Q120, 220, 320, 420	50363	MPSA12
Q121, 221, 321, 421	52217-001	2SC3298B-0
Q122, 222, 322, 422	52218-001	2SA1306B-0
Q123, 125, 223, 225, 323 325, 423, 425	5057	2SC3281
Q124, 126, 224, 226, 324 326, 424, 426	50571	2SA1302
Q127, 128, 227, 228, 327 328, 427, 428	S200-1530	MPSA43
	DIODES	
CR1	262114	1N4743A, 13V, Zener
CR2, 3-17, 19-22, 25-28 106, 107, 304	C13-0482	1N4148
CR23	50625	FEP30DP, Common Cathode Dual Diode
CR24	50624	FEN30DP, Common Anode Dual Diode
CR101, 201, 301, 401	C13-0482	1N4148
CR104	13-0686	IN4744A, 15V, ±5%, 1W, Zener
DS1, DS2	-----	Part of Ref. No. 125
DS100, 101, 102, 200, 201 202, 300, 301, 302, 400 401, 402	263008	LED, T1, RED, Ga AsP

ADJUSTMENT PROCEDURES



BIAS ADJUSTMENT

Connect Power (+12V-14.4V) to the amplifier and remote terminal. Leave the input and output connectors open.

Step	Terminals to be connected	Adjustment Location	Adjustment Method
1	Connect digital voltmeter across 1, 3 (bare wire leads of ER101)	VR102 Left Channel 1 Bias	Turn with small screwdriver for voltmeter reading of 13.2mV
2	Connect digital voltmeter across 1, 3 (bare wire leads of ER201)	VR202 Right Channel 1 Bias	Turn with small screwdriver for voltmeter reading of 13.2mV
3	Connect digital voltmeter across 1, 3 (bare wire leads of ER301)	VR302 Left Channel 2 Bias	Turn with small screwdriver for voltmeter reading of 13.2mV
4	Connect digital voltmeter across 1, 3 (bare wire leads of ER401)	VR402 Right Channel 2 Bias	Turn with small screwdriver for voltmeter reading of 13.2mV

CIRCUIT DESCRIPTIONS

SWITCHING REGULATOR

Power from the automobile's battery/alternator is filtered by L1 and CP13-CP30 and feeds the center tap of the primary winding of T1. Each end of the primary is driven by power MOSFETs Q10-Q15, which are turned on and off in alternate groups by U3. The secondary winding of T1 has its center tap tied to audio ground; the voltages at each end of the secondary are rectified by dual-rectifiers CR23 and CR24, and each polarity of pulsating DC is filtered by L2, L3, and CP31-CP34. Attenuated samples of the resulting positive and negative output voltages are combined at the inverting and non-inverting inputs of U3's error amplifier in combination with U3's 5.1 volt reference (via R5, R6, R9, R45, R51), so that, for equal current demands on both positive and negative rails, these rail voltages are regulated to 30 volts via pulse width modulation. Power for U3 derives from the battery/alternator after additional active filtering, overvoltage clamping, and switching via R1, R3, CR1, CP1, Q1, and Q3. The switching regulator frequency is set by R50 and C5 to about 45 kHz. Regulator transient response is controlled by R48, R49, C4, and C7.

The soft-start terminal of U3 is used for regulator enable and shutdown. CP3 charges slowly from U3's internal current source, slowly increasing the output pulse width. In shutting down, Q18 conducts to rapidly discharge CP3. Q18 is turned on when the remote line voltage falls below about 4 volts, or when the battery voltage is too low or too high, or when an excessive current demand is placed on the switching regulator, or when the heatsink temperature exceeds 90-C.

REMOTE SENSE AND MUTING

Amplifier power-up/power-down is controlled by the Remote Input voltage connected at J3-3. When this voltage rises above about 9 volts, U2 (74C14 hex schmitt-trigger inverter) pin 4 goes low, causing Q2 and Q3 to saturate. The collector of Q3 is the source of switched power, denoted as "SW+", which powers up U3, thus bringing up the rail voltages when Q3 saturates. The voltage drop across Q3 should be no more than 0.2 volts. The collector of Q2 also goes high, reverse-biassing CR2 and allowing CP11 to charge (in the absence of any other fault conditions, as will be described). Before the voltage on CP11 reaches about 9 volts, U2 pin 10 is high, keeping Q17 saturated and each of Q117, Q217, Q317, and Q417 saturated. In turn, each power amplifier's second-stage current-source transistors (Q116, Q216, Q316, and Q416) are kept off, which keeps the amplifier muted. In addition, Q17 sinks current through CR27 and R36 to illuminate the red "Protection" LED.

When the voltage on CP11 reaches 9 volts, U2 pin 10 goes low, turning off Q17; thus the Protection LED goes out and the amplifier current-source transistors conduct, which unmutes the amplifiers.

OVER/UNDERVOLTAGE SHUTDOWN

Voltages proportional to the battery/alternator input are generated by a voltage divider (R16, R17, R18) and are applied to inputs of two op amps (U1 pins 8, 9, 10, 12, 13, 14, 2/4 of quad op amp LM324), where they are compared to the 5.1 volt reference from U3. Hysteresis to prevent instabilities at thresholds is provided by R19 and R20. If the battery/alternator voltage exceeds 16.5 volts, U1 pin 8 goes high, and after a 0.1 second delay, U2 pin 12 goes low. CP11 discharges rapidly through CR14, returning the amplifier to the muted condition as described above. Also, Q18 is turned on, shutting the switching regulator down. If the battery/alternator voltage falls below 9.9 volts, U1 pin 14 goes high, and an identical sequence ensues.

THERMAL SHUTDOWN

The heatsink temperature in the vicinity of Q15 is sensed by TS1, an LM35DZ monolithic temperature-to-voltage converter IC, which has a 10 mV per -C conversion constant. The "GND" terminal of this device is connected to the R35/CR28 junction, a reference point shared by the voltage divider of R33, R34, and R65. The "Vout" terminal is filtered by R31 and C6 and applied to U1 pin 5; the voltage divider supplies U1 pin 6 with a comparison voltage via R64. When TS1's temperature reaches 90-C its output voltage exceeds the voltage at U1 pin 6, U1 pin 7 goes high, charging CP4 through CR19 and R13 and causing U2 pin 12 to go low. This mutes the amplifier, illuminates the Protection LED, and shuts down the switching regulator. In addition, Q6 is turned on through CR20 and R56, which then turns on Q16 and applies full power to the cooling fan. Since Q7 also turns on, the voltage at U1 pin 6 is reduced by voltage divider action (R44/R64) so that U1 pin 7 returns to the low

level when TS1's temperature reaches 65-C, if the amplifier's remote line remains high.

MUSIC-LINKED FAN CONTROL

When the Remote Input goes high at amplifier power-up, and SW+ rises to its nominal 12 volt level, Q6 and Q16 turn on momentarily due to CP10 charging through R63. Hence 12 volts is applied to the cooling fan via connector P1, and the fan starts. After a fraction of a second (unless TS1 temperature exceeds 90-C) Q6 and Q16 turn off, and the fan runs at a slow (practically inaudible) speed controlled by the voltage drop across R15.

When the temperature of TS1 exceeds 50-C, the voltage at U1 pin 3 becomes larger than that at pin 2, and pin 1 goes high. If any channels of the amplifier have peak output signals of 3 volts or more, Q5 turns on, U2 pin 2 goes high, and Q6 is turned on via R23, CR17, and R56. Q16 also turns on and full voltage is applied to the fan, which runs at maximum speed. Fan noise remains inaudible in normal listening conditions due to masking by program material. When the program material is interrupted, Q5 turns off, U2 pin 2 goes low, and Q6 and Q16 turn off, returning the fan to the slow speed condition.

Note: The TC400Q is a four-discrete-channel amplifier. Except for a distinction between left and right channels that will be described, each signal amplification channel is identical to any other channel in every respect. Corresponding component reference designators are denoted by three digits following the letter(s) that denote component type; the first digit is 1, 2, 3, or 4, corresponding to each of left 1, right 1, left 2, and right 2, respectively. For ease of the following discussion, we discuss operation of the left 1 channel, with reference designators R1XX, CR1XX, C1XX, etc. The discussion applies directly to each of the other three channels without modification, except where otherwise stated.

LINE LEVEL AMPLIFIERS

Input signals from source components are connected to the amplifier at RCA jacks labelled "INPUT 1" and "INPUT 2". For each of the left channels (marked "L"), the center conductor connects to the non-inverting input of the associated line level amplifier stage via R156, VR103, CP110, and R100, for the INPUT 1 left channel, or via R356, VR303, CP310, and R300, for the INPUT 2 left channel. The shield conductor of each of these channels connects to the inverting input of that amplifier stage via R157, CP111, and R101, or R357, CP311, and R301. The amplifier stage converts this differential signal to a single-ended one with a gain of unity for 1.0 k2 source impedances.

For each of the right channels (marked "R"), the center conductor connects to the inverting input of the associated line level amplifier stage via R256, VR203, CP210, and R201, for the INPUT 1 right channel, or via R456, VR403, CP410, and R401, for the INPUT 2 right channel. The shield conductor of each of these channels connects to the non-inverting input of that amplifier stage via R257, CP211, and R200, or R457, CP411, and R400.

Since left and right channel signals are thus amplified internally with opposite polarities, proper overall polarity from each input to each output is restored by reversing speaker polarity at right channel outputs. This should be kept in mind when testing with ground-referenced equipment; for example, a grounded-low-side oscilloscope or meter should have its high-side connection made to the "-" speaker terminal for right channels, as these are the actual outputs of the right channel power amplifier stages.

The unity-gain differential-to-single-ended stages are a three-transistor design, consisting of an NPN input (Q100) with shunt feedback to its emitter; the collector drives the base of PNP device Q101 with linearizing local feedback from R110. The output is the junction of the PNP collector and a constant-current load provided by Q102. The current is determined by the 0.9 volt difference between the base-emitter voltage of Q102 and the forward voltage of DS102 (a GaAsP LED), and the value of R111. Since the input differential signal is capacitively coupled this stage can be used in an op-amp-like configuration as a differential amplifier by applying signals to both the base and emitter of Q100. For best common-mode rejection in the presence of a source resistance unbalance, VR103 provides a compensating adjustment for center-conductor source impedances up to 1.0 kΩ.

The second stage of the line level section consists of a similar three-transistor circuit with variable gain determined by the setting of VR100. The gain is given by 1 plus the ratio of R116 to the parallel equivalent resistance of R115, and the sum of R105 and the adjusted resistance of VR100. At the setting for maximum gain, with VR100 fully clockwise (equal to the endstop resistance, typically a fraction of an ohm), the gain is therefore 1 + (8.87/(39.20.909)) = 11.0; with VR100 fully counterclockwise, 1 + (8.87/(39.2100)) = 1.31.

This stage is followed by a passive attenuator and a third stage used for a variable bass boost centered at 50 Hz. The gain of the third stage with the "50 Hz EQ" control fully counterclockwise (flat position) is 1 + (15.8/(15.8100)) = 2.16. Taking the attenuation of 0.453 into account, the overall gain from line level input to this output stage is about 10.7 for maximum gain, 1.28 for minimum gain. When the 50 Hz EQ control is adjusted to its maximum clockwise position, the bass frequencies centered around 50 Hz are boosted by 15 dB. This is achieved by a synthetic RLC network in shunt with VR101 and R123 (R127, C106, C107, R128, R129, and the unity-gain amplifier stage (Q108, Q109, and associated components).

Power supply rails for the line level sections are supplied by an emitter-follower and zener diode for the positive rails (Q131, CR104, and associated components), and IC negative voltage regulators (U101 and associated components for left 1 and right 1 channels, U301 and associated components for left 2 and right 2 channels).

POWER AMPLIFIERS

The output from the last line level amplifier stage is coupled via CP108 and R112 to the base of Q110, which is the non-inverting input of the power amplifier. The amplifier topology is an NPN differential pair (Q110, Q111) whose differential output drives a PNP differential pair (Q113, Q117). The collector current of Q113 passes through common-base-connected Q114 and drives a current-mirror stage consisting of Q115, Q118, R149, and TC400Q Circuit Descriptions

R154. Q118 and Q117 drive the "Vbe multiplier" (Q120, R159, VR102, and R160), R152, R153, and the bases of common-collector driver devices Q121 and Q122. CP118 and CP119 connect across the bases of the driver devices. In turn, Q121 and Q122 drive the bases of paralleled common-collector output devices Q123, Q124, Q125, and Q126. R161 increases the emitter current of the drivers over the base current of the output devices alone. Current sharing and current sensing is provided by dual ballasting resistors ER100 and ER101. Overall negative feedback is applied via R146, C109, and attenuated by R145; CP117 ensures that the overall amplifier has unity gain at d.c. The net overall (closed-loop) gain of the power amplifier section, including the input attenuation, is 9.9.

Power amplifier differential stages have local feedback via emitter resistors R138, R140, and R148, R151; emitter current is supplied by temperature-compensated current sources (Q112, R139, R143, and DS100; Q116, R144, R150, and DS101). Muting of audio and associated output shutdown is achieved by Q119 turning on and saturating, reducing the collector current of Q116 to zero. This results in no more than small leakage currents flowing in the driver and output devices, unless the outputs are actually forced above or below ground by more than 1.2 volts.

PROTECTION CIRCUITRY

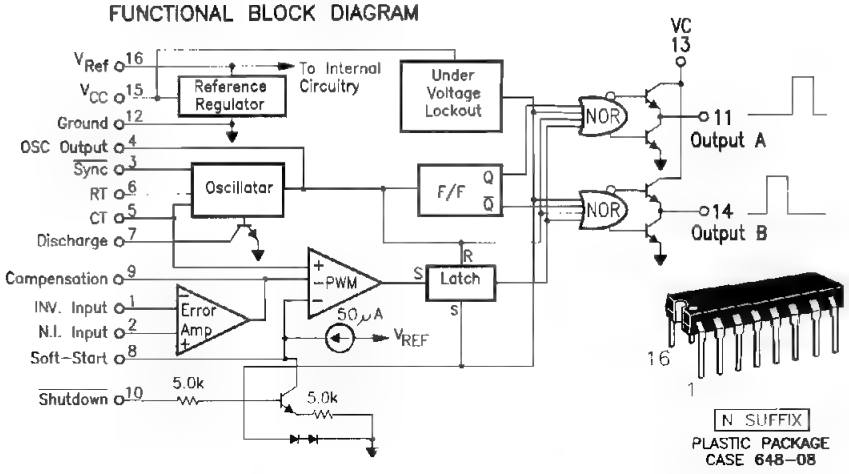
Two levels of protection are available in the TC400Q. Amplifier output currents are sensed, full-wave rectified, and both linearly summed (over four channels) and independently threshold-detected and "OR'ed". The linear sum currents produce a voltage across R66; if this voltage has an average value in excess of the upper threshold of U2 pin 5, this gate's output will go low and turn off Q9 and hence turn on Q18, shutting the switching regulator down. This indicates an overall excess current demand on the power supply. On the other hand, a single overcurrent condition on the left 1 amplifier output will turn on Q130 and cause U2 pin 8 to go low. This induces a muting event by discharging CP11 as has been described above, without shutting down the switching regulator.

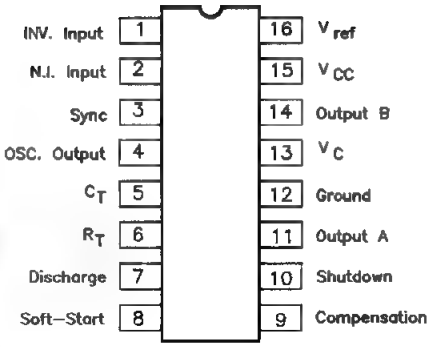
The current sensing works by sensing the voltage drop across ER100 and ER101 due to output current, using R162, R168, R169, R170, and Q127 to develop a proportional-to-current-magnitude voltage across R164. Additional Q127 emitter current is supplied by Q128. Q129 outputs a positive current proportional to the magnitude of output current. The voltage at its emitter drives voltage divider R166 and R167 and this reduced voltage is applied to the base of Q130. An overcurrent condition thus causes Q130 (or the corresponding device in each of the other three channels) to conduct, and induce a muting event as described above. Owing to the negative temperature coefficients of base-emitter voltage of Q127, Q129, and Q130, the threshold of muting is reduced at high amplifier temperatures.

IC FUNCTIONAL BLOCK DIAGRAMS

SG3525A Pulse Width Modulator Control Circuit

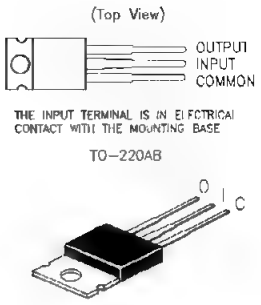
FUNCTIONAL BLOCK DIAGRAM

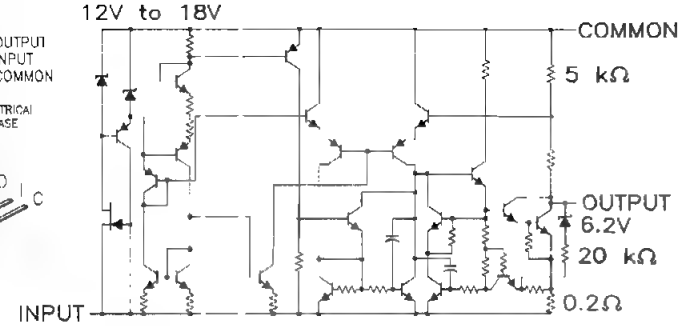




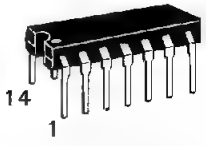
(Top View)

LM7915 Negative-Voltage Regulator

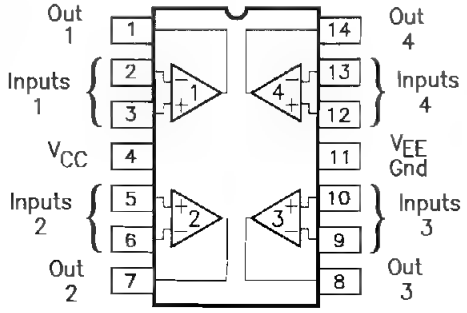




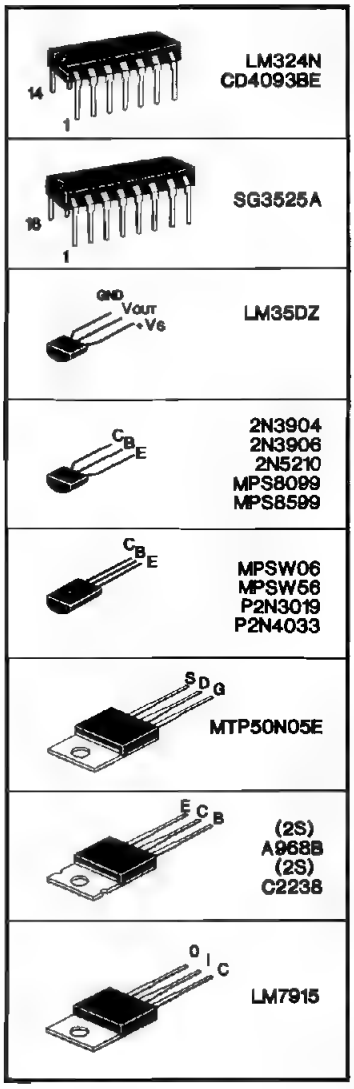
LM324A(N) Quad Differential Input Operational Amplifier

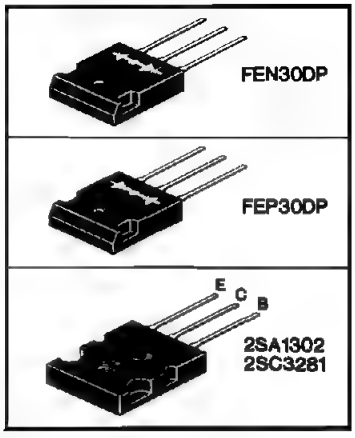


N SUFFIX
PLASTIC PACKAGE
CASE 646-06
(LM224, LM324, LM2902 ONLY)

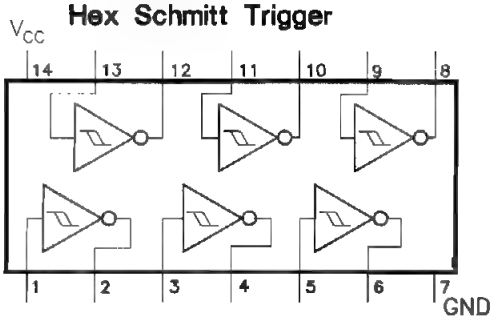


(Top View)

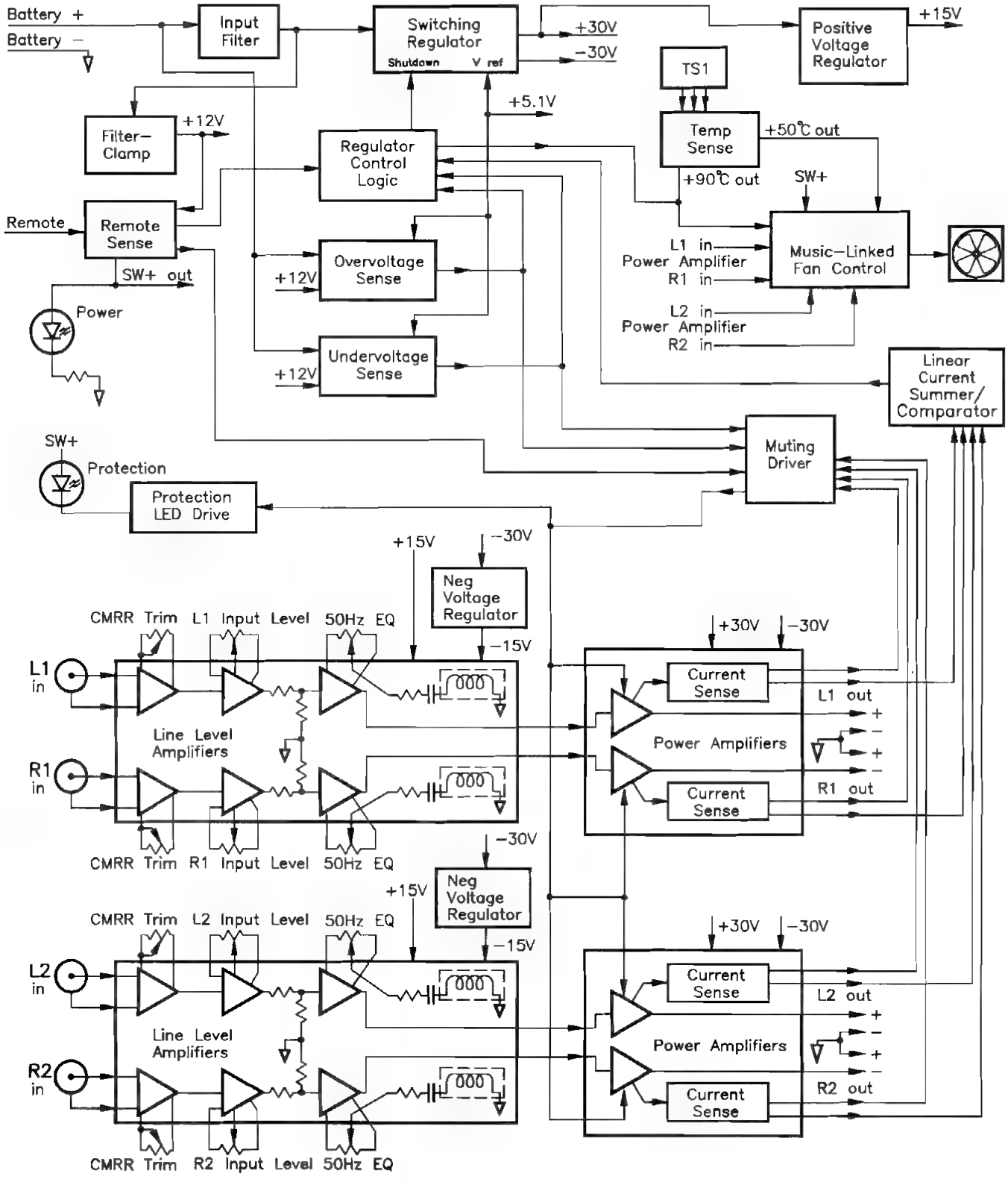




MM74C14 Hex Schmitt Trigger



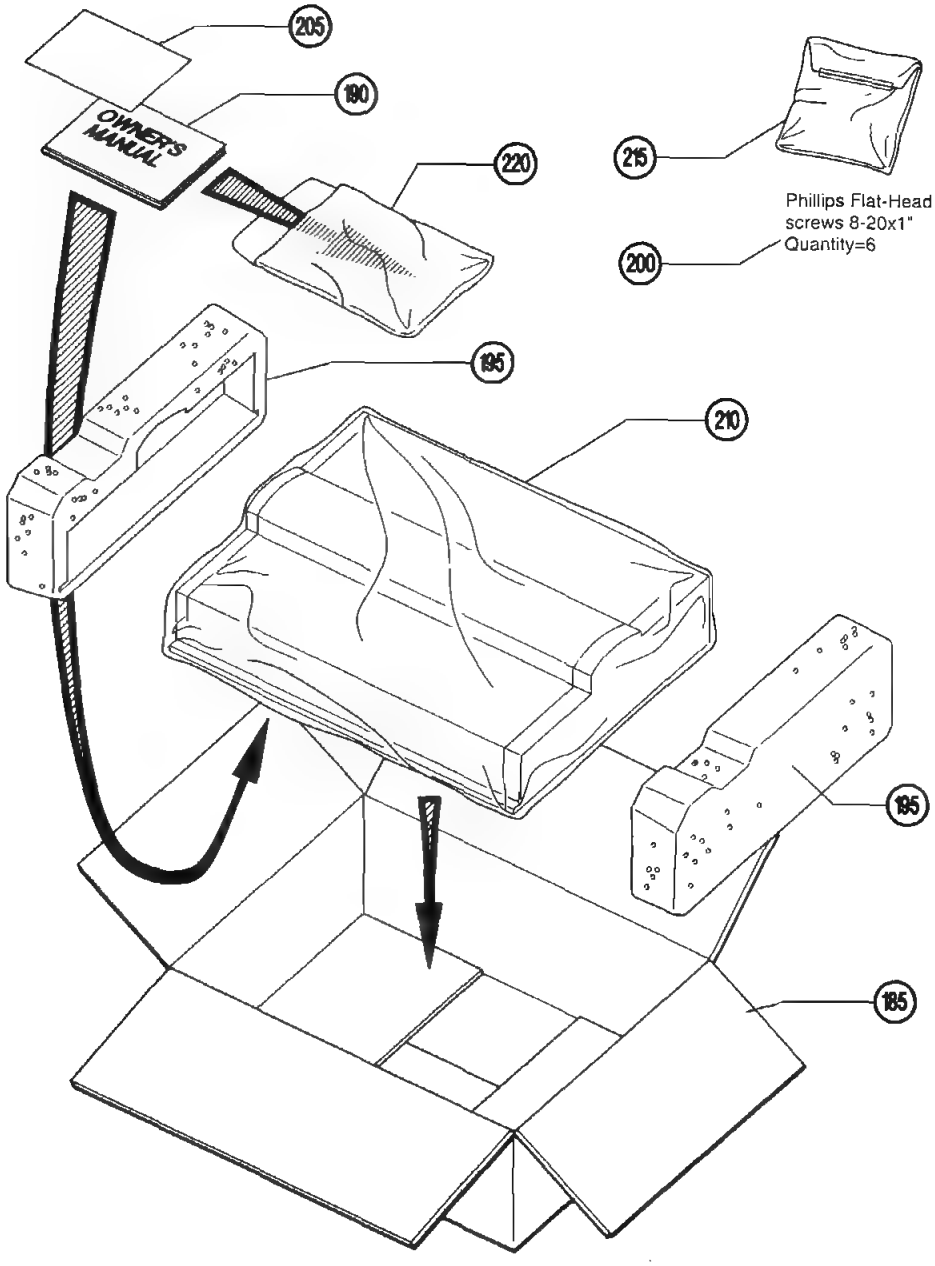
BLOCK DIAGRAM



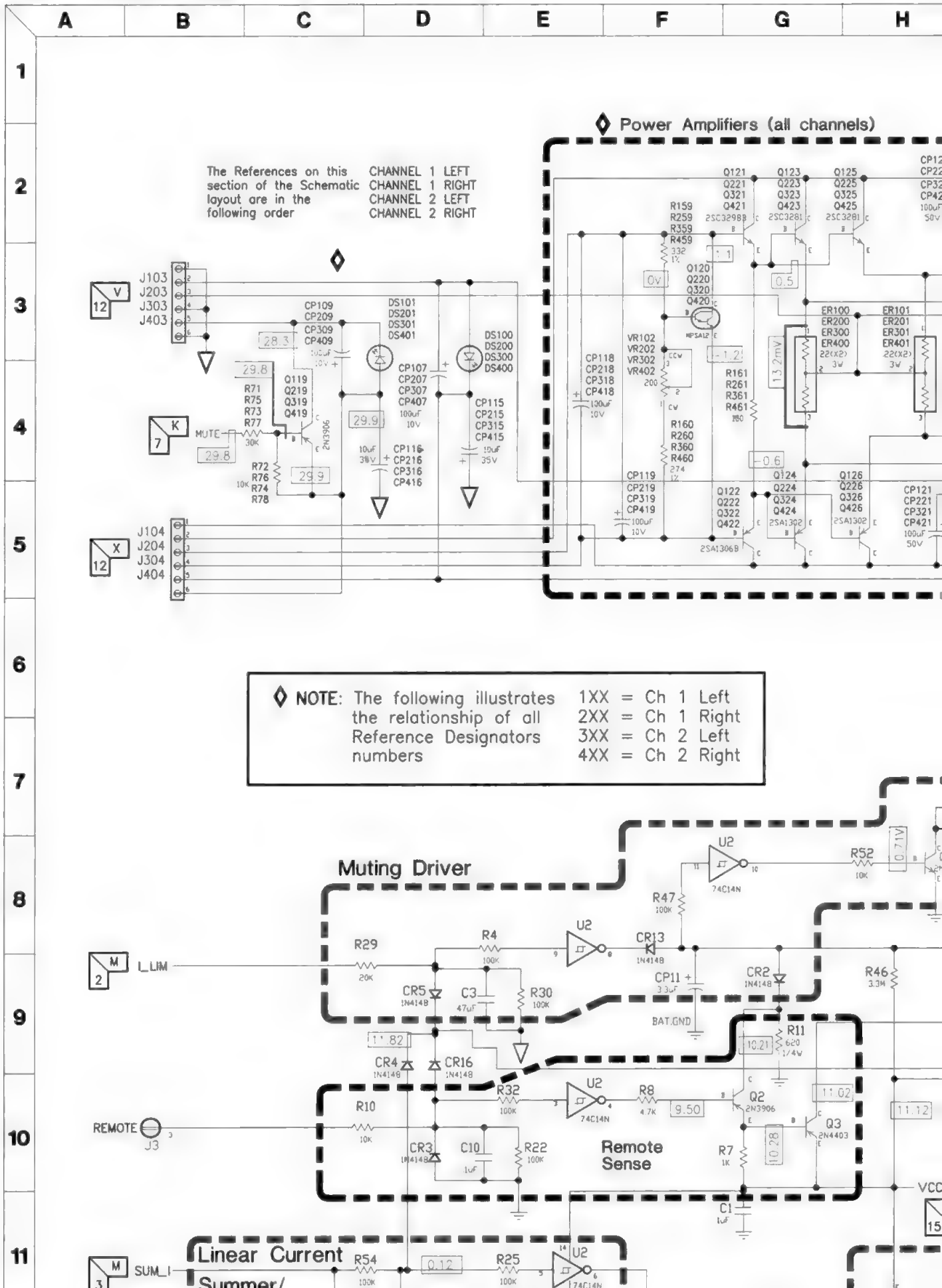
PACKAGE PARTS LIST

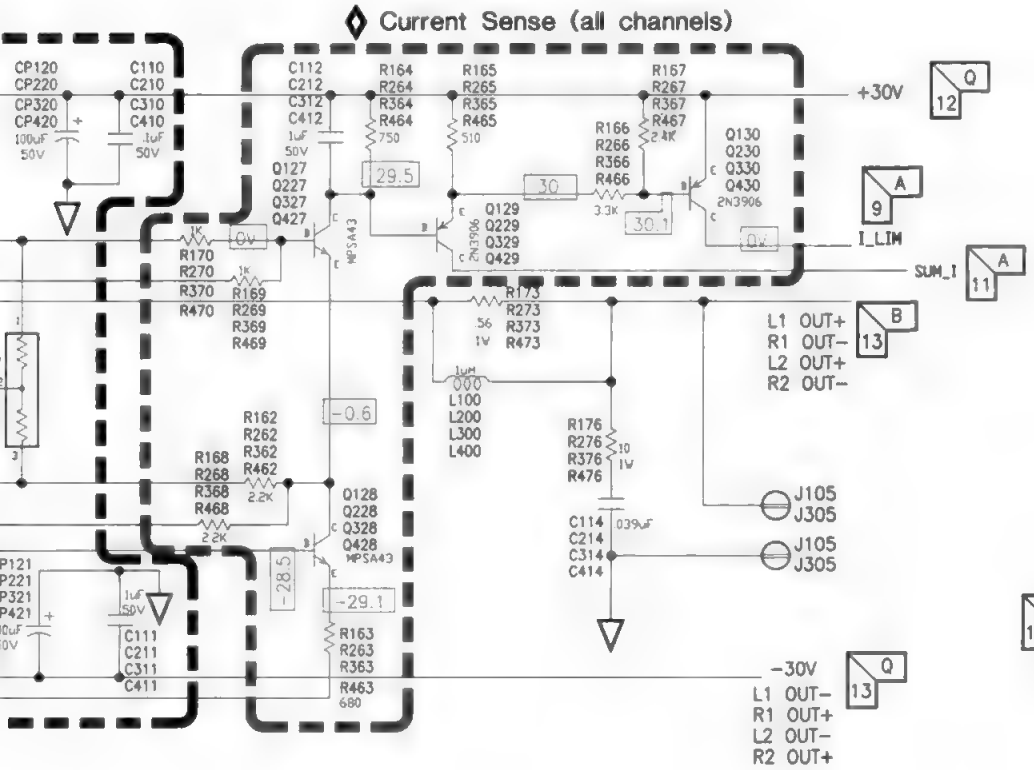
Ref. No.	Part No.	Description
185	265524	TC400Q Display Box (Black)
	265513	TC400Q Display Box (Silver)
190	50609	Owner's Maunual
195	50610	Foam Packing
200	51308	Installation Screws
205	51387	Warranty Stations List
210	51647-001	15"x24" Poly Bag .004
215	P900-15214	2"x2" Poly Bag .002
220	P900-15215	7"x10" Poly Bag .002

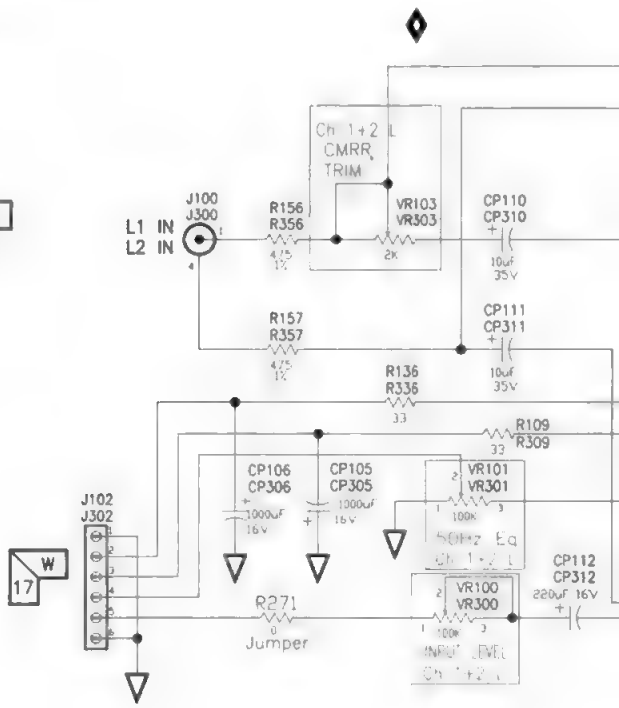
PACKAGE ASSEMBLY

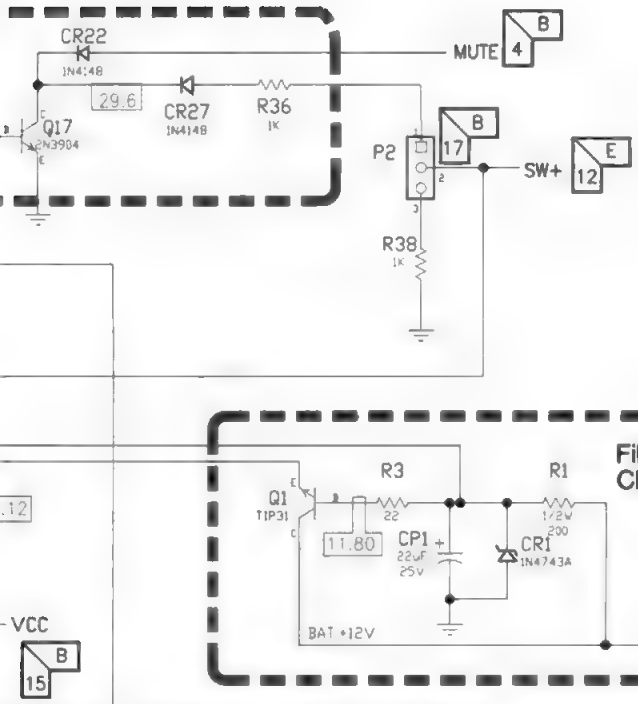


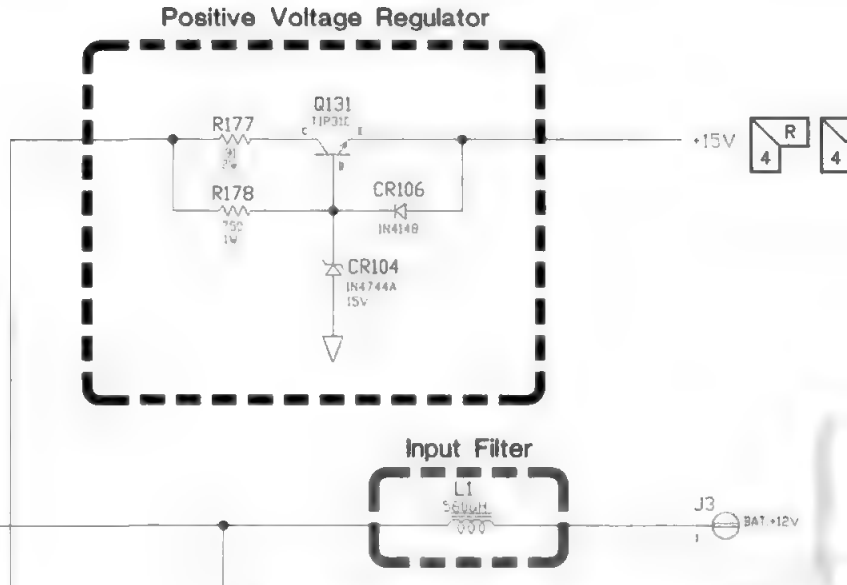
SCHEMATIC DIAGRAM




Current Sense (all channels)
+30V
I_LIM
SUM_I
L1 OUT+
R1 OUT-
L2 OUT+
R2 OUT-
-30V
L1 OUT-
R1 OUT+
L2 OUT-
R2 OUT+
J105
J305


L1 IN
L2 IN
CMRR TRIM
Jumper


MUTE
SW+
Filter-Clamp
VCC
Regulator Control Logic


Positive Voltage Regulator
+15V
Input Filter
BAT +12V

Q R S T U V W X Y

1 2 3 4 5 6 7 8 9 10 11

◊ Stereo/Mono

◊ Negative Voltage Regulator

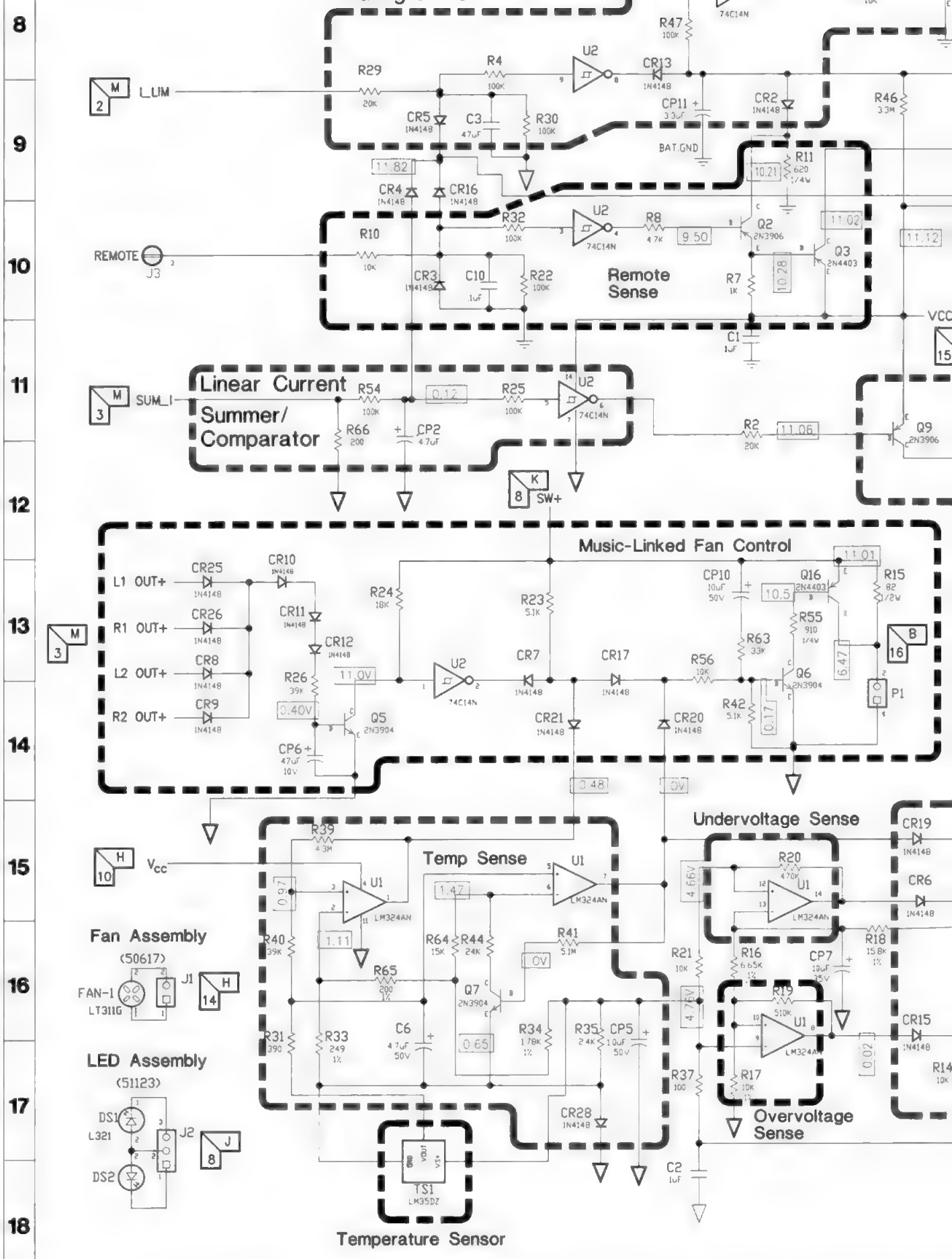
◊ Power Amplifiers (all channels)

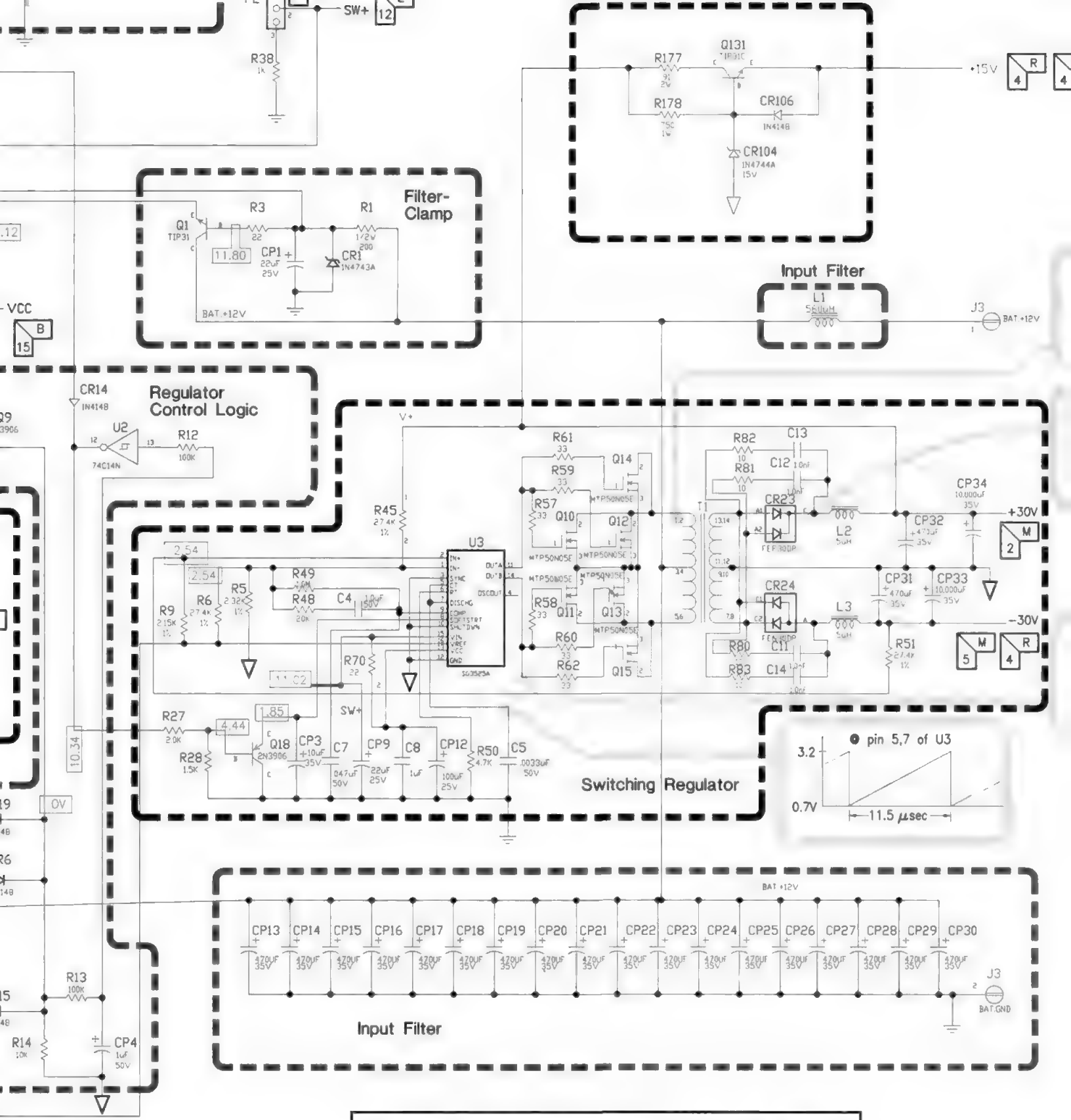
The References on this section of the Schematic layout are in the following order

CHANNEL 1 RIGHT
CHANNEL 2 RIGHT
CHANNEL 1 LEFT
CHANNEL 2 LEFT

33 ● "1,2" of T1 0V 23 µsec

46V ● "C" of CR23 30V


L_LIM
REMOTE
J3
SUM_I
Linear Current
Summer/
Comparator
Remote
Sense
SW+
Music-Linked Fan Control
L1 OUT+
R1 OUT+
L2 OUT+
R2 OUT+
Undervoltage Sense
Overvoltage
Sense
Temp Sense
Vcc
Fan Assembly
(50617)
FAN-1
LT311G
LED Assembly
(51123)
DS1
L321
DS2
TS1
LM35DZ
Temperature Sensor
NOTE: Voltage measured with +12 volts connected to +12 volt power and re

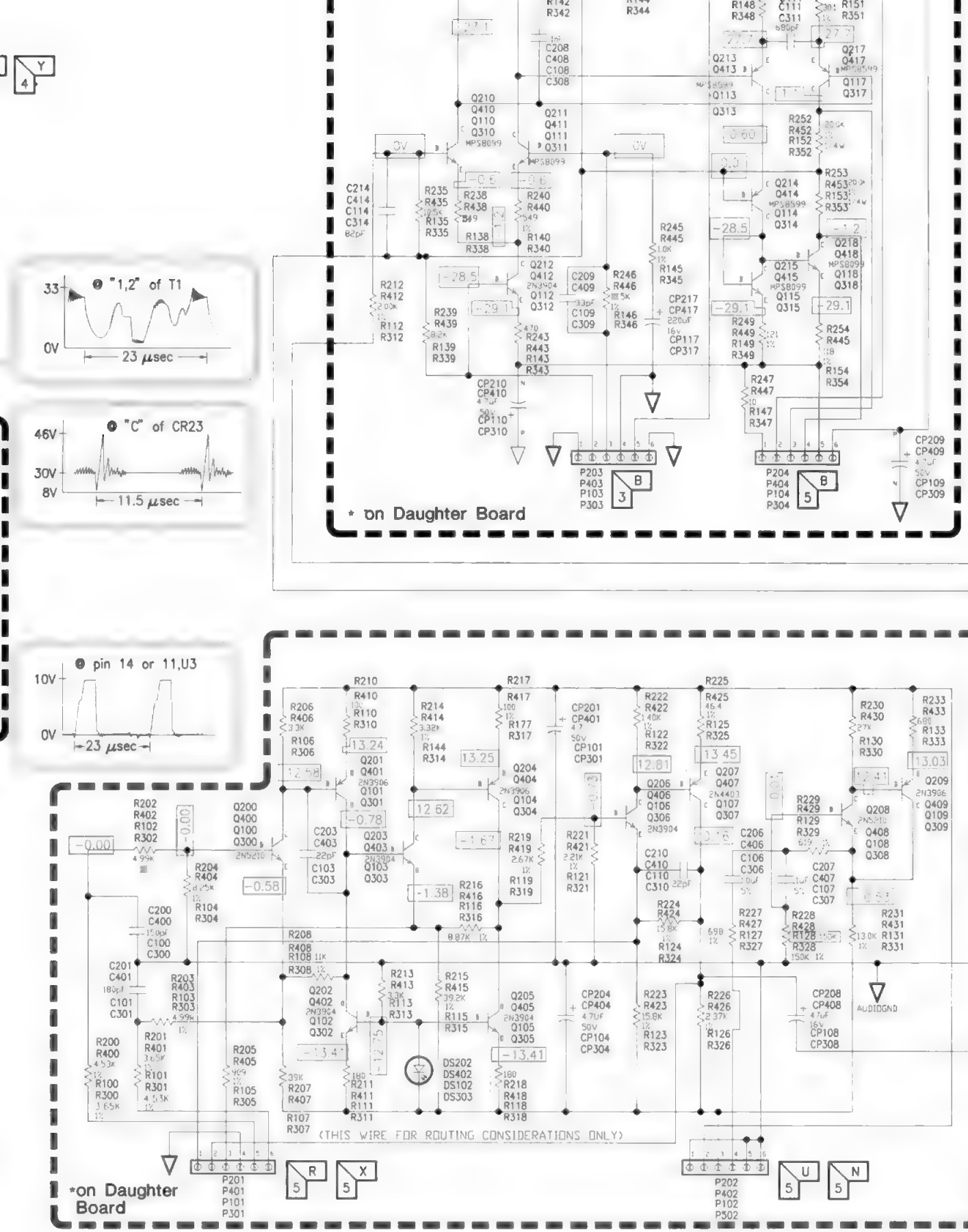


◊ NOTE: The following illustrates the relationship of all Reference Designators numbers

1XX = Ch 1 Left
2XX = Ch 1 Right
3XX = Ch 2 Left
4XX = Ch 2 Right

remote inputs. No Audio Inputs or Outputs connected.

	I	J	K	L	M	N	O	P	Q

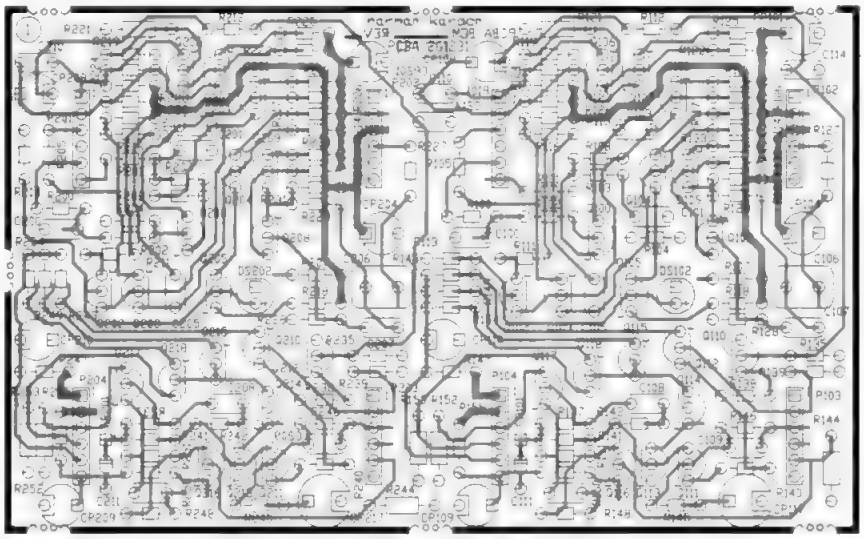


◊ Line Level Amplifiers (all channels)

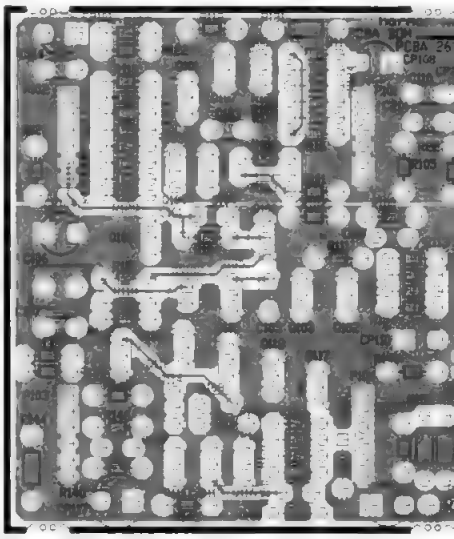
The References on this section of the Schematic layout are in the following order

CHANNEL 1 RIGHT
CHANNEL 2 RIGHT
CHANNEL 1 LEFT
CHANNEL 2 LEFT

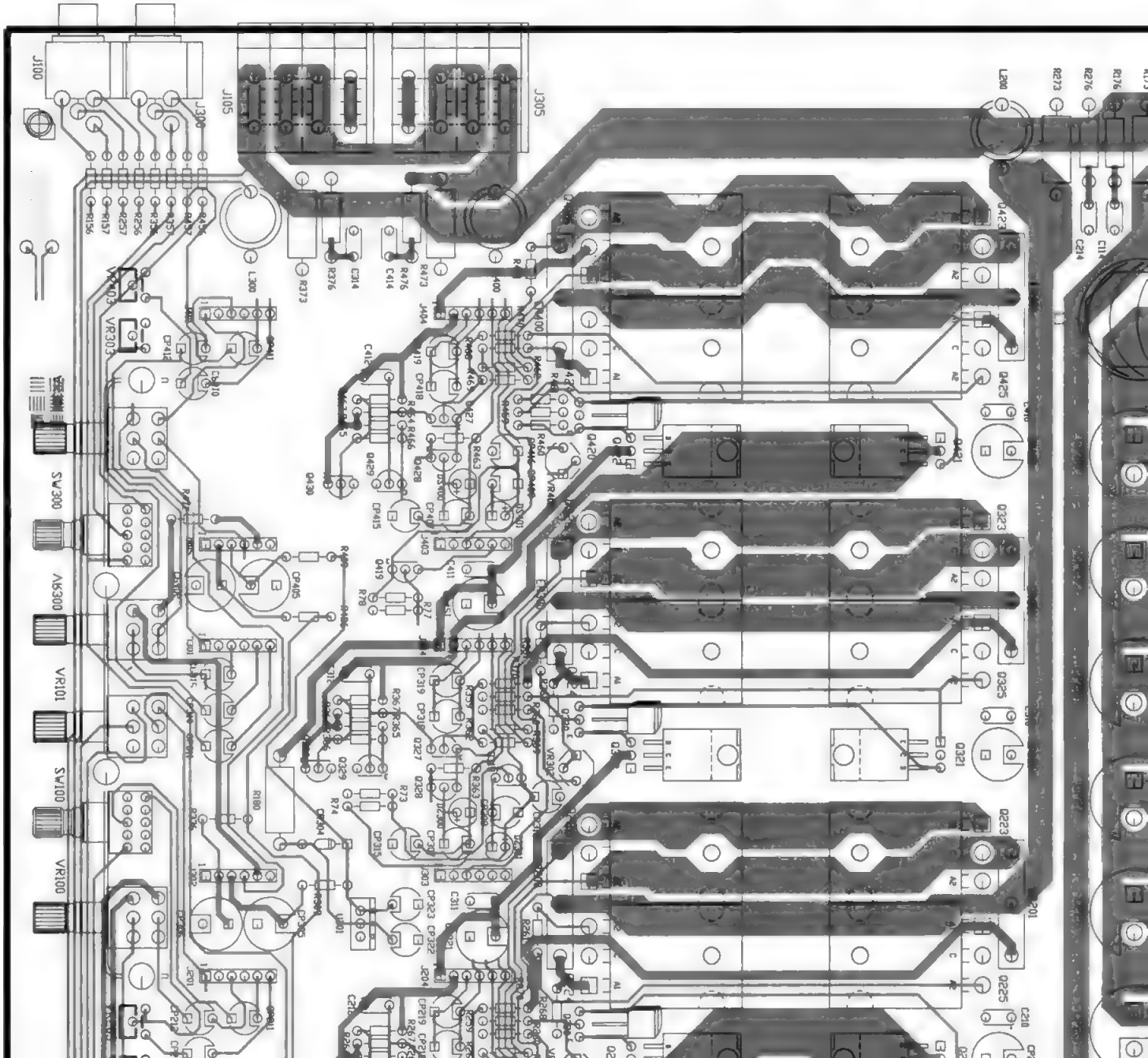
WIRING DIAGRAM



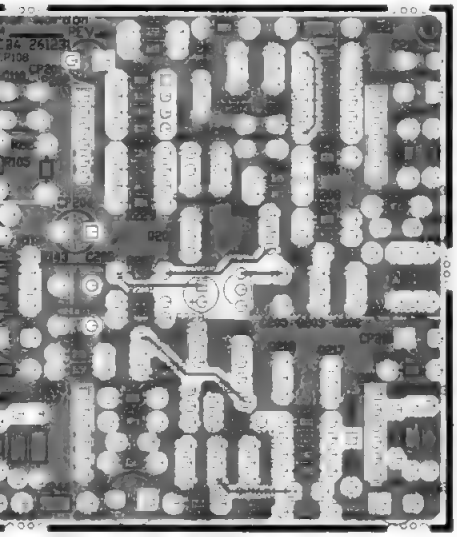
Daughter Board 1 viewed from solder side



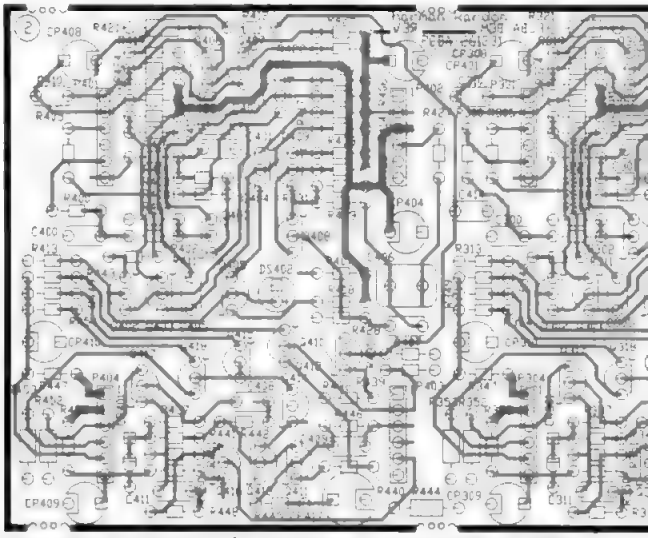
Daughter Board 1 viewed from co



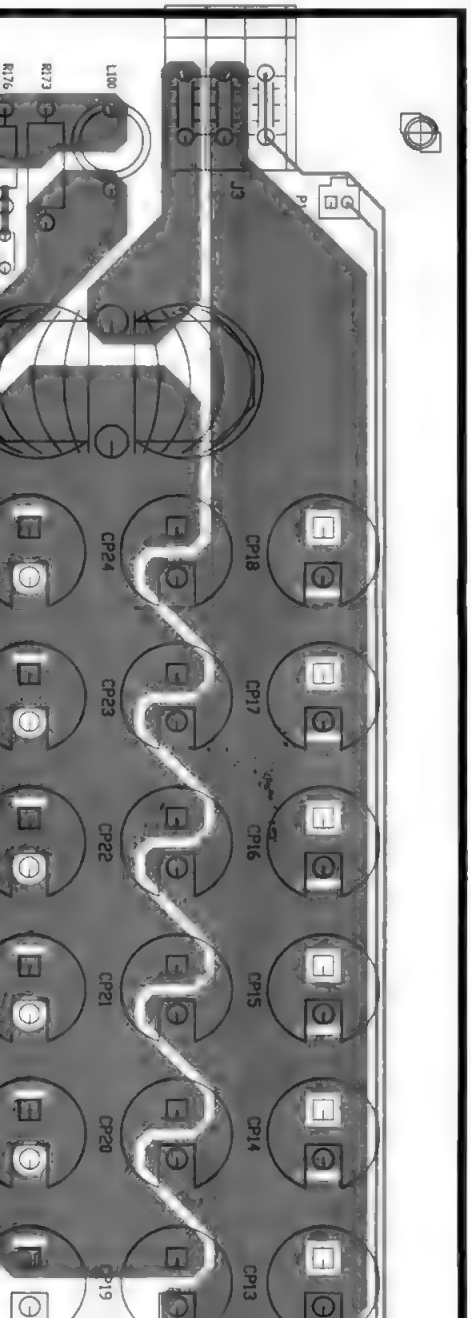
J	K	L	M	N	O	P	Q	R



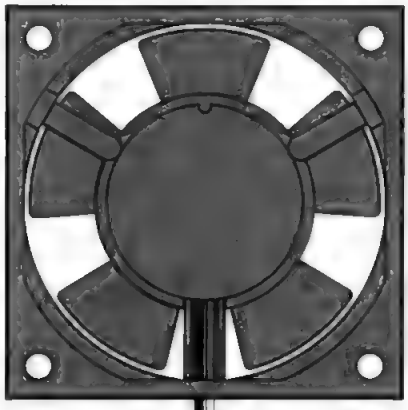
n components side

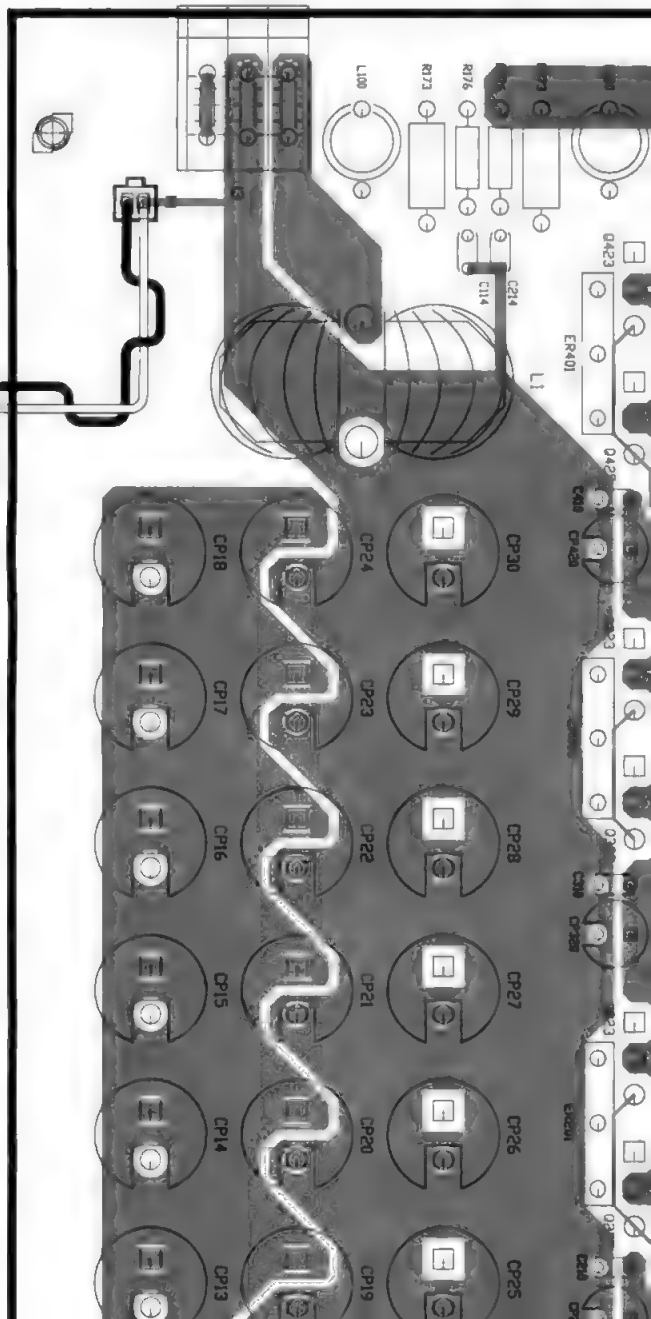


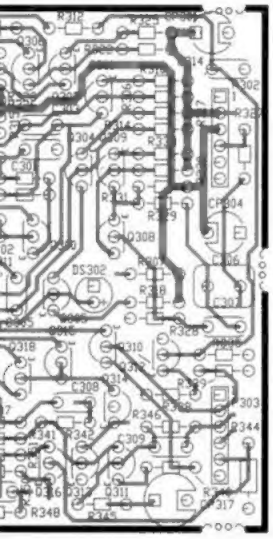
Daughter Board 2 viewed from solder side

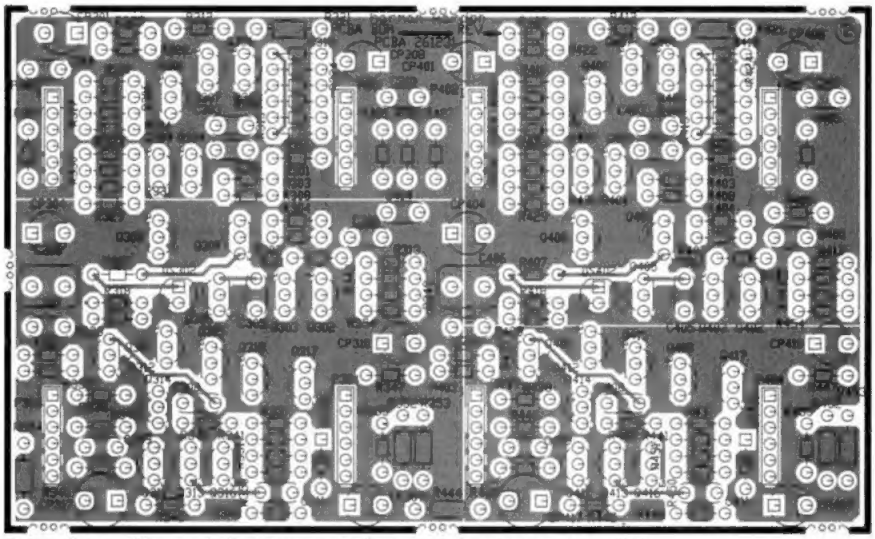


Fan Assembly
ref. #120
part #50617

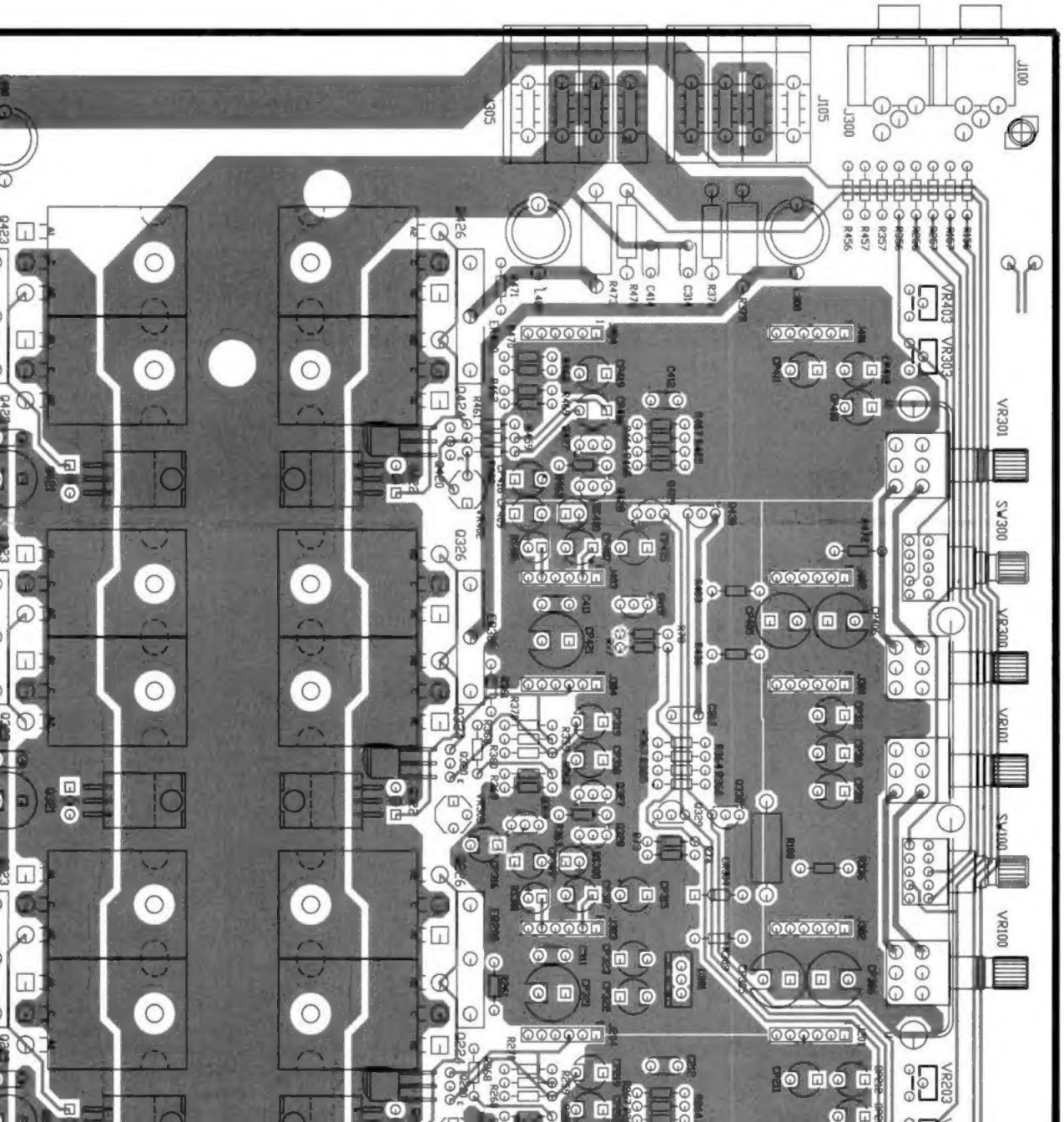


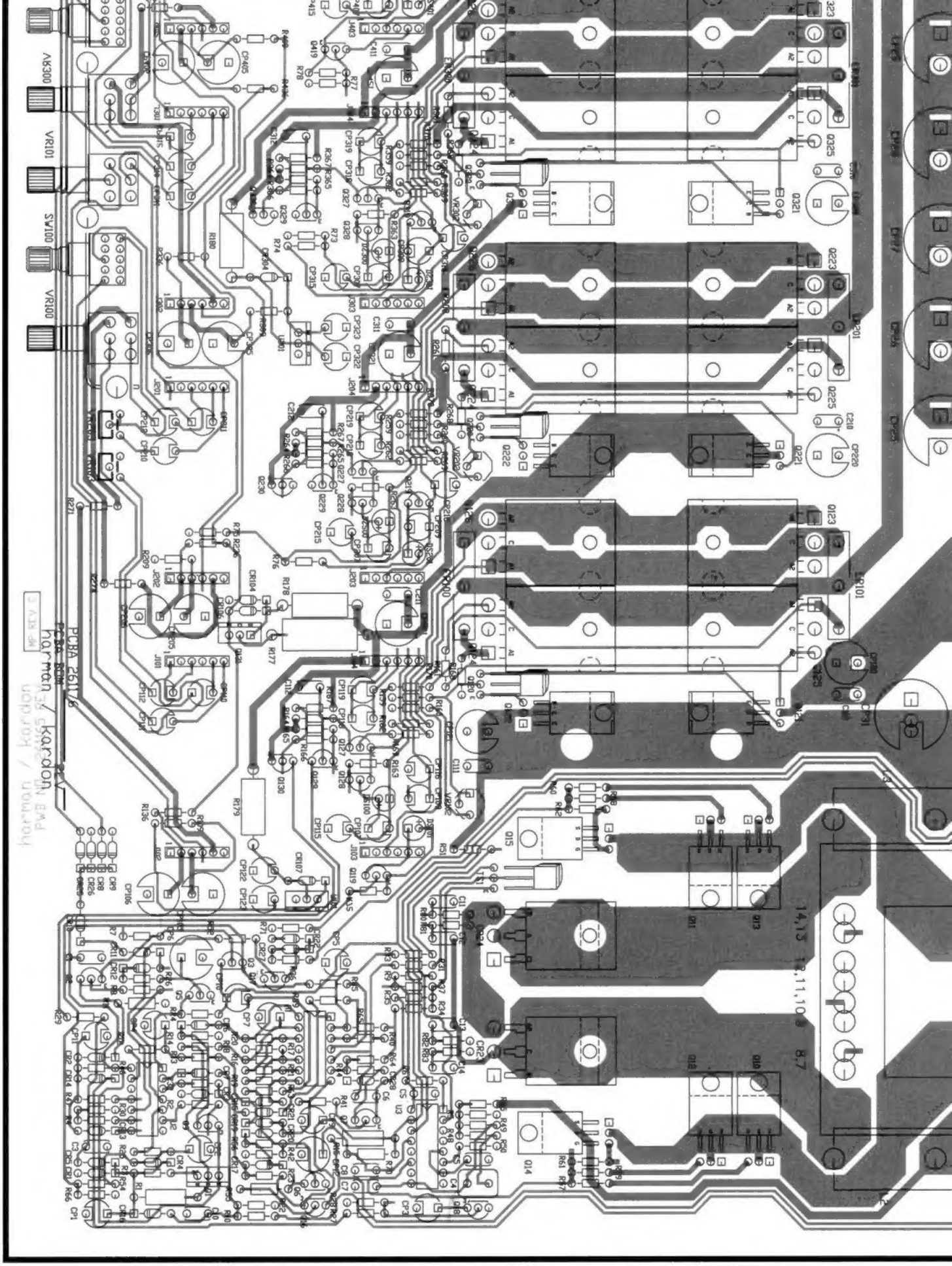






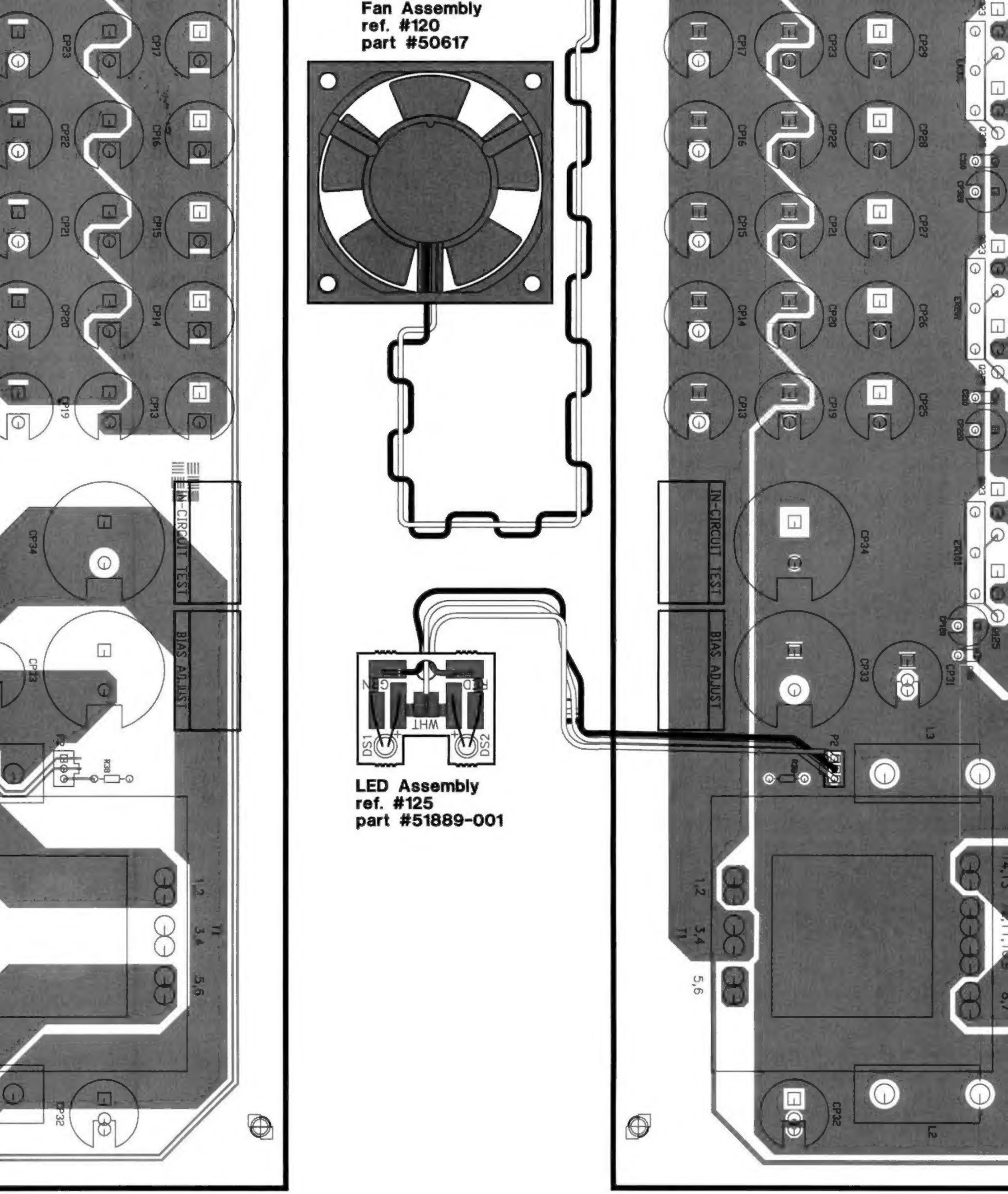
Daughter Board 2 viewed from components side





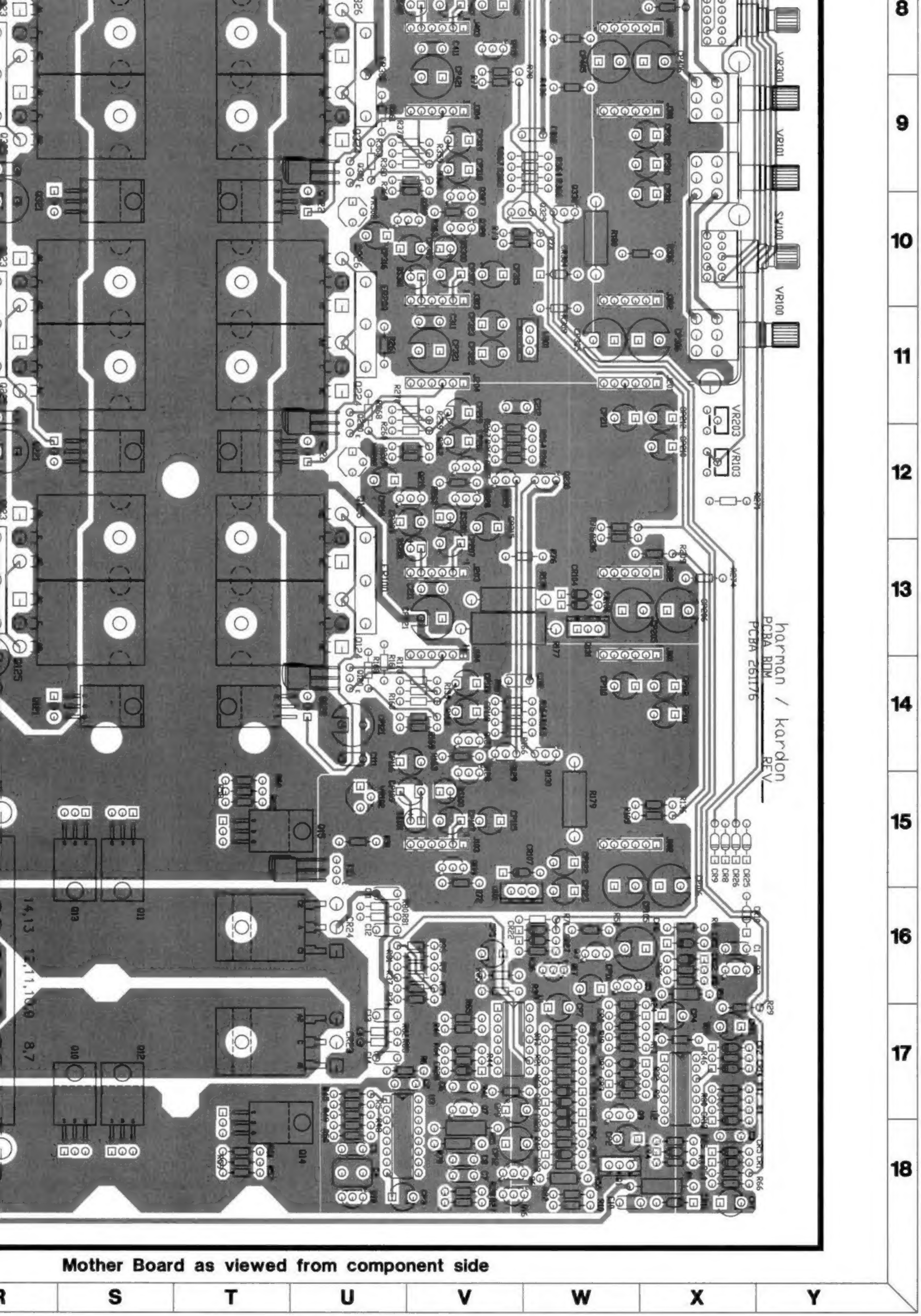
Mother Board as viewed from solder side (viewing through Board to see silk s

A	B	C	D	E	F	G	H	I



lk screen)

J	K	L	M	N	O	P	Q	R



Mother Board as viewed from component side